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ADAPTATIONS TO EXERCISE OF NEGRO AND WHITE SHARECROPPERS IN COMPARISON WITH NORTHERN WHITES

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IN 1938 Robinson (1) described a procedure for experimentally assessing physical fitness, and set up standards for various age groups of white male subjects that serve as a basis of comparison in a study of other groups of corresponding ages. The present study is an application of Robinson's procedure in measuring physiological adaptations to work of young male sharecroppers in the Mississippi Delta. As a basis for evaluating the performance of the sharecroppers, the data published by Robinson (1) on white subjects from Boston and vicinity will be referred to frequently as the Boston study. Additional measurements are being reported on

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white students: 39 men at Indiana University between the ages of 17 and 24 years.

The sharecroppers used as subjects in this study comprise 52 normal Negroes between the ages of 8 and 24 years, and 8 white men, ages 18 to 21. For purposes of comparison the Negro subjects have been classified according to age into groups described in Table 1. These groups

TABLE 1

Characteristics of subjects

GROUP	NUMBER OF SUBJECTS	AGE IN YRS. Mean	AGE IN YRS. Extremes	WEIGHT IN KG. Mean	WEIGHT IN KG. Extremes	STATURE IN CM. Mean	STATURE IN CM. Extremes
			A. Negro sharecroppers				
N II A	12	9.9	8–11.6	29.1	20–34	137.4	124–154
N II B	6	12.5	12–13	34.5	33–37	148.4	146–153
N III	9	14.4	13.1–16	45.2	33–61	160.5	145–182
N IV	11	17.5	16.1–20	55.7	41–65	172.0	153–180
N V	14	22.1	20.1–24	63.9	58–72	173.3	165–181
			B. White sharecroppers				
WS	8	19.1	18–21	64.6	54–71	176.5	170–186
			C. White students, Indiana University				
W IV Ind.	14	18.9	17–20	67.9	55–83	176.2	168–188
W V Ind.	25	22.0	20.1–24	65.6	55–77	174.7	163–187
			D. Whites in Boston				
W II B	10	10.5	8.2–12.6	29.5	25–39	137.2	131–149
W III B	11	14.1	13.1–15	55.8	41–67	165.7	155–171
W IV B	12	17.4	16.1–19	68.4	55–88	179.2	172–190
W V B	11	24.5	20.1–29	72.5	61–84	178.4	170–188

are numbered to correspond with similarly numbered age groups described in the Boston study, with two exceptions. Group II includes ages from 8 to 13 inclusive in the Boston study, but in the case of Negroes it is subdivided into Group N II A, including boys from 8 to 12, and Group N II B, composed of boys 12 to 13 years of age. Group V includes ages from 20 to 29 in the Boston study but in the Negroes N V is made up of subjects 20 to 24 years of age inclusive. The white sharecroppers comprise a single group, WS, their ages ranging from 18 to 21 years. The Indiana students are described in Table 1 in the

two age groups designated W IV Ind. and W V Ind. Table 1 also contains the data from the Boston study on Groups W II B, W III B, W IV B, and W V B, of white subjects comparable in age ranges with the subjects in this study.

The boys in W II B were not greatly different from the Negroes of Groups N II A and N II B in respect to height and weight (Table 1). The older colored boys were markedly lower than the northern whites in weight and somewhat lower in stature: they were more slender. The white sharecroppers were also more slender than the Boston whites of the same ages. In stature and weight the adult sharecroppers more nearly approached the averages of 171.4 cm. and 64.2 kg. reported by Davenport and Love (2) for the first 1,000,000 U. S. Army recruits in 1917 than did the Boston whites, who were taller and heavier. Davenport and Love found the average stature in 6,454 Negro troops to be 171.99 cm. and the average weight in 49,503 agricultural Negro males to be 64.25 kg.

The same tests of physical fitness were given the sharecroppers of this study and the Indiana students as in the Boston study. The subject came to the laboratory in the post-absorptive state and, after resting for 30 minutes in the recumbent position, performed two grades of work on a motor-driven treadmill set at an angle of 8.6 per cent. Each subject walked at 5.6 km. per hour for 15 minutes; this raises the metabolic rate about 7 times its basal level. Only 16 of the Indiana students were given this test. After resting for 10 minutes, each subject ran at a rate which would exhaust him in 2 to 5 minutes. For all subjects of Group II the speed of the run was 9.34 km. per hour except for three in Group N II B who ran at 11.3 km. per hour. All of the older subjects, both sharecroppers and students, ran at 11.3 km. per hour. The observations made will be apparent from the data. The methods used have been described by Robinson (1) with only two exceptions: the Evelyn photoelectric colorimeter has been used in reading the color in the sugar determinations, and Edwards' revision of the lactic acid method (3) has been adopted. The sharecroppers went through the experiments when the mean dry bulb temperature ranged around 30°C. and the humidity 80 per cent, while the northern whites performed the work under ordinary laboratory conditions with the temperature around 22-25°C.

The average duration of exhausting work for the subjects of the various age groups in this study is presented in Table 3. These data

reveal a superiority of the Negroes between 14 and 19 inclusive over the Boston white subjects of the same ages in ability to sustain hard work, the average duration in Groups III and IV being 4.5 and 4.3 for the Negroes and 3.2 and 3.8 for the whites, respectively. Within the same age range the white students of Indiana University were about equal in ability to the Negroes. From age 20 the Negroes were not superior. Their run averaged 3.9 minutes as compared with 4.4 for the Indiana students, 4.5 for the Boston study, and 3.9 for a group of 27 Harvard sophomores. We may conclude that the sharecroppers, both white and colored, were as capable of sustaining this run as were the northern whites.

THE HEART RATE IN MODERATE WORK

In the heart rates attained in moderate work the Negroes between 8 years of age and maturity showed the same general trend downward with advancing age which was noted in the Boston whites. Fig. 1A represents the means of the heart rates of Groups N II A, N II B, and N III and two extreme individual records. The mean rates at the end of the walk of Groups N II A and N II B were 167 and 162 respectively, close to the mean of 164 for the corresponding Boston boys. Group N III of the Negroes attained a mean rate of 152 as compared with 163 in W III B of the Boston whites and 167 in measurements by Dill and Brouha (4) on ten boys between 13 and 15 years of

FIGURE 1

FIG. 1. A. THE HEART RATE OF NEGRO SHARECROPPERS IN MODERATE WORK: A WALK AT 5.6 KM. PER HOUR ON AN 8.6 PER CENT GRADE

Two diverse records of boys 8 and 14 years old are compared with the means of Groups N II, aged 8–12; N II A, aged 12–13; and N III, aged 13–15. The means are derived by averaging the rates of all members of the groups at arbitrarily selected times. Note the higher rates of the younger boys.

B. THE HEART RATES OF WHITE SHARECROPPERS AND OF OLDER NEGROES IN MODERATE WORK

The mean heart rate of the Negroes averages lower than that of the whites.

C. THE HIGHEST HEART RATE ATTAINED DURING MAXIMAL WORK RELATED TO AGE IN WHITES AND IN NEGRO SHARECROPPERS

The lines represent the relation of heart rate to age calculated by the method of least squares.

D. DIVERSE INDIVIDUAL RECORDS OF THE HEART RATE OF NEGRO SHARECROPPERS IN MAXIMAL WORK COMPARED WITH THE MEANS OF NEGROES N V AND OF THE WHITE SHARECROPPERS WS

HEART RATE
A
B
C
D
WORK
CR-8
N IIA
N IIB
N III
ST-14
N V
WS
JC-17
N IV
TG-21
20MINS.
WHITE •
NEGRO △
NEGRO
WHITE
AGE
20 YRS. 24
CA-20
o END WORK
START
RR-9
12 MINS. 16

FIGURE 1

age doing exactly the same work. The low heart rates of the Negroes of this age may be attributed to training because they had been field workers for 4 or 5 years previously. It may also be related to an earlier physiological maturity: Negroes of N II B may have been physiologically more nearly comparable to Group W III B than to W II B of the whites. Factors of race, age, and training may each play a part in this difference in heart rate during moderate work.

In Fig. 1A it may be seen that the average rates 1 minute before work were 106, 100, and 87 for Groups N II A, N II B, and N III respectively, as compared with 123, 120, and 115 at the start of work. Corresponding mean rates on the whites of W II B and W III B were 84 and 85, and 93 and 98. Thus even though the resting rates were higher in the Negroes, the anticipatory rise was greater. While this may depend in part on previous experience by the whites, none of the younger white boys had been through experiments on the treadmill.

Acceleration of the heart rate during the early part of the walk was different in the whites and Negroes under 13 years only because the latter had higher rates before work began; one minute after work started their rates were about the same. The increment of heart rate in the first minute of work was about the same in Negroes 13 to 15 years of age as in younger Negroes though as stated above they had lower rates before work started.

Fig. 1B reveals that at the end of the 15-minute walk Groups N IV and N V of the Negroes attained respective mean heart rates of 142 and 146, values close to the means of 150 and 144 in the corresponding age groups in the Boston study, and somewhat lower than a mean of 156 found by Dill and Brouha (4) in 16 young white men in Boston. The average for the white sharecroppers was 154. We believe that in male subjects of a given age, the heart rate in performing this grade of work is an indication of the physical fitness, especially of cardiovascular efficiency. As evidence of this, Robinson (5) found that 5 highly trained distance runners performed this work with heart rates averaging 111, with extremes of 103 and 115, and that the efficiency in energy transformation was the same in the runners as in non-athletes. However, any difference of rate in favor of the Negro sharecroppers may not be a direct measure of cardiovascular efficiency since, as will be proved below, the total energy expenditure in this walk was lower in the Negroes than in the whites; hence their energy requirements for circulation were less. The anticipatory rise in heart rate tended to be

greater in the older sharecroppers, both white and colored, than in the Boston whites. In correlation with their higher resting rates and anticipatory rise, the groups of sharecroppers attained higher rates by the end of the first minute of work. As work went on, the white sharecroppers experienced a greater rise than did the Negroes, as appears in Fig. 1B. Recovery was at about the same rate in Groups IV and V of both Negroes and Boston whites, but was notably slow in white sharecroppers.

THE HEART RATE IN MAXIMAL WORK

Fig. 1C shows individual maximal heart rates of 76 whites and 50 Negroes, between the ages of 8 and 24 years. The whites include 34 from the Boston study, the others being the Indiana students and the white sharecroppers. Fig. 1C also shows separately for whites and Negroes the trend of maximal heart rate with advancing age by straight lines calculated by the method of least squares. In this age range the maximal heart rate is independent of age in both races, whereas Robinson had previously found in Boston that boys attained higher heart rates than men. The white men of the present study and the Negroes above 13 years of age accumulated much higher blood lactates (Table 4) and thus were more completely exhausted and more likely to have attained their highest possible rates than the younger subjects. As evidence of this we found that in 58 whites between 16 and 24 years of age the correlation between blood lactate and maximal heart rate was 0.36 ± 0.07. In further support of the idea, it may be noted that the Indiana students attained a mean maximal heart rate of 200.1 as compared with 200.5 in the 24 Negroes between 16 and 24 years of age and the students' lactates were also much higher than the Boston whites attained (Table 4). The average maximal heart rate of all the Negroes was 201.1, and of all whites 197.3. Extreme individual variations were from 168 to 219 in the whites and from 165 to 256 in the Negroes. Thus we find from the data of both studies that in this age range the maximal heart rates attained in exhausting work depend principally on individual characteristics and to a lesser extent on the degree of exhaustion reached, and possibly on age and race. The significant trend downward with age occurs in later decades.

The variations occurring in the sharecroppers' individual records during the experiments are similar to those presented for whites in the

Boston study. In Fig. 1D are presented two extreme individual records beginning 2 minutes before work started and showing the heart rate throughout work and during a 9-minute recovery period. One of these is the record of C. A., a Negro 20 years of age, who attained a rate of 256 beats per minute at the end of the run. This is the highest rate we have ever recorded on a healthy man and was attained after only 2 minutes and 40 seconds of work. It should be noted that this man's heart rate before work and during the last half of the recovery period was considerably below the average for his age and that during moderate work his rate was about 10 beats lower than the average. His heart was probably not as efficient or as powerful as the heart of the average individual because he was able to supply only 80 per cent as much O_2 per kg. of body weight as the average Negro of his age. The men who had low maximal heart rates had relatively high O_2 intakes during exhausting work. In 58 white men, ages 16 to 24, the correlation between maximal heart rate and highest O_2 intake in cc. per kg. of body weight was -0.44 ± 0.07. Since O_2 supply in this kind of work is closely dependent upon cardiac output, we may infer that, as a rule, men whose maximal heart rates are low have more efficient hearts and greater heart output in hard work than men with high maximal rates.

The mean anticipatory rise, acceleration, and recovery for the white sharecroppers and N V are indicated in Fig. 1D. The anticipatory rise before work was slightly greater in the older sharecroppers than in the younger Negroes. The Boston study also showed a greater anticipatory increase in heart rate in young adults than in boys. The initial heart rates were lower and the mean acceleration in the first minute of work was greater in the older than in the younger Negroes. Recovery in the first minute after the end of work was most rapid in the youngest boys (N II) but showed no general relation to age; thereafter the return toward the original rate was about the same in all Negroes but was more rapid in them than in white sharecroppers.

We may conclude that the heart rates in exhausting work show a rather close similarity between the two races, particularly in acceleration and deceleration. There is also a similarity in the variability of the maximal heart rates attained (Fig. 1C). The most noteworthy difference seems to be a tendency for Negroes to attain higher maximal rates than the whites.

TABLE 2

Performance in moderate work

Each subject walked for 15 minutes at 5.6 km. per hr. on a grade of 8.6 per cent. The mean value for each group (as described in Table 1) is given.

GROUP	O_2 INTAKE (l/min.)	O_2 INTAKE (cc./kg./min.)	R.Q.	RESPIRATORY RATE	LUNG VENTILATION* (l/min.)	LUNG VENTILATION* (l/kg./min.)	(TIDAL AIR × 100) ÷ (VITAL CAPACITY)
			A. Negro sharecroppers				
N II A	0.86	29.6	0.87	51	28	0.95	28
N II B	0.97	27.5	0.89	43	28	0.81	29
N III	1.18	26.0	0.90	38	31	0.70	31
N IV	1.37	24.6	0.89	30	33	0.60	32
N V	1.58	24.1	0.89	31	39	0.60	31
			B. Eight white sharecroppers				
WS	1.69	26.1	0.91	24	38	0.59	32
			C. Sixteen white students, Indiana University				
W IV and W V	1.71	26.7	0.92	26	39	0.62	32
			D. Whites in Boston				
W II B	0.95	32.2	0.89	42	27	0.92	31
W III B	1.54	27.6	0.89	34	43	0.76	36
W IV B	1.89	27.7	0.90	29	49	0.72	36
W V B	1.96	27.1	0.91	26	48	0.67	37
			E. Eight champion runners				
W V R	1.74	26.6	0.86	24	35	0.53	27
			F. Two Negro servants, Mississippi				
N V S	2.00	26.3	0.89	27	47	0.61	34
			G. Sixteen Negro students, Indiana University				
N IV Ind. and N V Ind.	1.79	26.2	0.91	28	44	0.63	35

* Volumes at 37° C., 760 mm. Hg and saturated with water vapor.

METABOLISM AND LUNG VENTILATION IN MODERATE WORK

The O_2 requirements in the moderate work are given in Table 2. When related to body weight, the mean O_2 consumption of the Negro sharecroppers was greatest in the youngest boys and gradually decreased up to maturity, being only four-fifths as great in men as in boys. This depends only to a minor extent on basal metabolism. After allowing

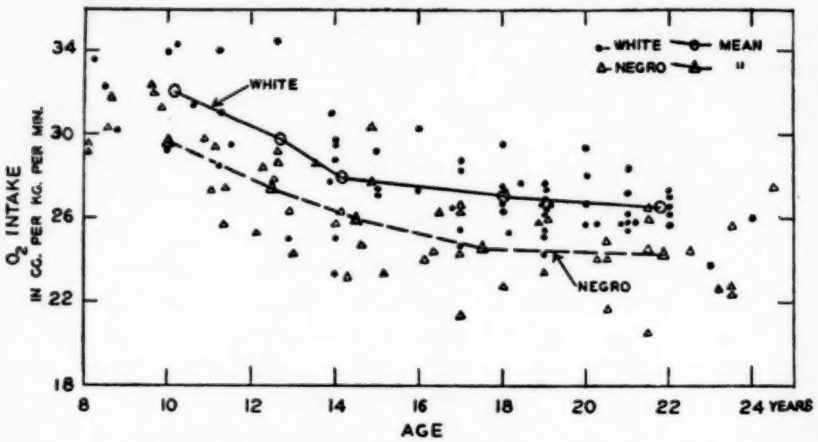

FIG. 2. THE O_2 REQUIREMENT OF NEGRO SHARECROPPERS AND WHITES IN MODERATE WORK

Note that the means of the age groups of whites, connected by continuous lines, are consistently higher than corresponding means of Negroes.

for the decline in basal metabolism, we find that the relative O_2 requirement was still 12 per cent greater for Group N II A than for N V. A corresponding decline in efficiency from age 8 to maturity was found in the white subjects of the Boston study. The white sharecroppers were less efficient than the adult Negroes, requiring a mean of 26.1 cc. of O_2 per kg. as compared with an average of 24.3 for 25 of the older Negroes (Table 2). This difference is not due to a difference in basal metabolism, for Thompson, Robinson and Gedgoud (6) found an average of —2 per cent in the adult Negroes and +5 per cent in the white sharecroppers as compared with the Aub and DuBois standards. This difference in basal metabolism would account for a difference of 1 per cent between the efficiency of the white sharecroppers and of the Negroes, whereas

the actual difference between their mean O_2 requirements in the walk was 7.4 per cent.

Fig. 2 presents an interesting comparison of all the Negroes with all the Boston Whites, ages 8 to 24 years, combined with the 8 white sharecroppers and 16 Indiana students. The mean O_2 requirements of the various age groups of whites were consistently higher than those of corresponding groups of Negro sharecroppers. The average for the entire group of 68 whites including all ages was 27.9 as compared with 26.2 in the 52 Negroes. The greater efficiency of the Negroes may depend in part on their training in the cotton fields and possibly on the absence of excess fat. However, the white sharecroppers were equally slender and had similar training. Furthermore, we have found that highly trained distance runners, including Lash, Deckard, Cunningham, Trutt, Fenske, and others, did this walk with an average O_2 consumption of 26.6 cc. per kg., which is about the same as is required by other white men (Table 2). On the other hand, the mean O_2 requirement of 16 northern Negro college students was 26.2 cc. per kg., and that of 2 young southern Negroes who did only indoor work was 26.3, values which are very close to the mean of northern white students and higher than the means of Negro sharecroppers of the same age range (Table 2). These northern colored students commonly are of mixed parentage: many of them are predominantly white. We advance very tentatively the hypothesis that the trained Negro of relatively pure racial stock is more skillful in walking and climbing than the white man.

Robinson (1) proved that a balance between CO_2 production and output is maintained by normal young subjects in this age range during the period of measuring metabolism in these experiments: the *R. Q.* measures the proportions of carbohydrate and fat being burned. Table 2 reveals that the average *R. Q.* in moderate work fell within the remarkably narrow limits of 0.87 and 0.92 for the groups of boys and men of both races and both environments, not including the champion runners. The average *R. Q.* for all 52 Negro sharecroppers was 0.89 with a standard deviation of 3.6 as compared with an average of 0.90 $\pm$ 3.9 in 73 whites, ages 8 to 24. The fuel in this sort of work is about three-fifths carbohydrate, a considerable increase over the proportion used in the fasting state at rest. Elevation of the *R. Q.* by moderate work in adults has been previously noted by several authors, as reviewed by Robinson (1).

It was pointed out in the Boston study that in white subjects from 6 to 25 years of age the *R. Q.* in moderate work does not increase with increasing blood lactic acid, but that above age 25 there is a positive correlation between *R. Q.* and lactate. We find in the Negroes, whose ages were from 8 to 24, that there is no correlation (0.08 ± 0.09) between lactatic acid and *R. Q.* in the walk. We also find that there is no correlation (0.02 ± 0.09) between *R. Q.* and blood sugar in the Negroes.

There is a rapid decline in lung ventilation in relation to body weight as well as of respiratory rate with advancing age up to maturity in the Negro sharecroppers (Table 2). A similar, though less pronounced, trend was found in the Boston whites. In general the Negroes performed the moderate work with about the same lung ventilation as the northern whites, the mean of all 52 Negro sharecroppers being 0.72 liters per kg. of body weight as compared with 0.73 in the Boston and Indiana white subjects between 8 and 29 years of age. The white sharecroppers and the adult Negroes were relatively lower in lung ventilation than the northern whites of the same ages, while the youngest Negroes were higher than the youngest whites.

The decline of respiratory rate with advancing age in the young Negroes was mentioned above. Respiratory rates during the walk were generally somewhat higher in the Negro sharecroppers than in whites of similar ages despite the fact that the whites had slightly greater ventilation (Table 2). The Boston whites of Groups II—V had mean rates of 42, 34, 29, and 26 respectively, as compared with 48, 38, 30, and 31 in the Negroes. In fact, tidal air was a smaller fraction of the vital capacity in the Negroes than in the whites (Table 2) even though their vital capacities were significantly lower than the whites', as will be described elsewhere.

METABOLISM AND LUNG VENTILATION IN MAXIMAL WORK

The average capacities of subjects in the various groups for supplying O_2 in severe work are related to body weight in Fig. 3, which includes the individual values of maximal O_2 intake in cc. per kg. of body weight per minute for all the Negroes, the white sharecroppers, 39 Indiana students, and the 39 Boston whites between the ages of 8 and 24 years. The white subjects were slightly superior to the Negroes in this important physiological measurement. The average for the entire group of 76 whites, including all ages, was 51.5 cc. of O_2 per kg. with

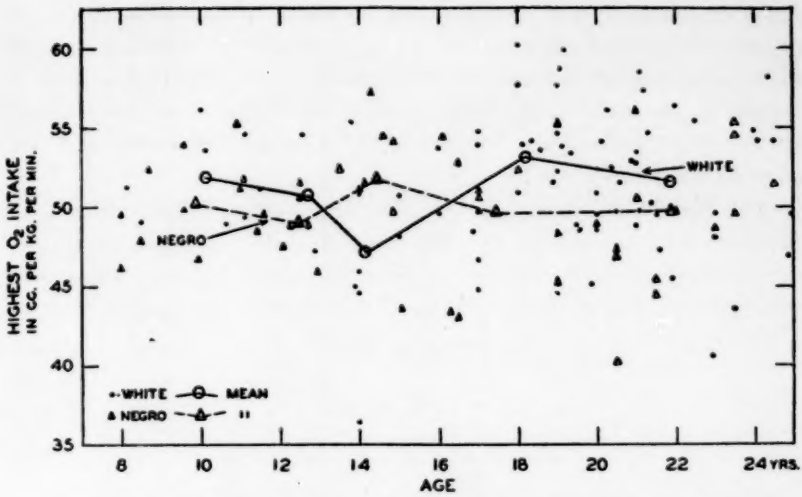

FIG. 3. THE HIGHEST O_2 INTAKE ATTAINED BY NEGROES AND WHITES DURING MAXIMAL WORK

a standard deviation of 4.5 as compared with 49.6 in the white sharecroppers, and 49.9 ± 3.7 for all the Negro sharecroppers. The difference between the mean of all Negroes and the mean of all whites was 1.6 with a standard error of 0.73. The differences may be related to the high temperature and humidity of the environment in which the Negroes were examined. This imposed an extra circulatory burden; more blood was diverted to the skin for heat dissipation in the Negroes thereby reducing to some extent the blood supplied to the working muscles and thus, the work being maximal, restricting the O_2 consumption.

The Boston adolescents (Group III) had a lower capacity for supplying O_2 in exhausting work than that of pre-adolescent or of post-adolescent boys. We found in this study a slightly lower capacity for O_2 supply in Negro boys between 12 and 13 years of age than in the younger or older boys. (Fig. 3.) Thus it occurs about 1½ years earlier in the Negroes. However, we have not enough data to be certain; many more measurements are required because of relatively wide variability in the capacity for O_2 consumption.

Since the energy available for sustaining a run of this speed and duration is derived about equally from the O_2 consumed and the "oxygen debt", it is interesting to note in 58 whites, ages 16 to 24 years,

a correlation of 0.75 ± 0.04 between maximal O_2 consumed in cc. per kg. per minute and duration of the run. Since this relation exists it might be expected that the Boston whites with their higher average oxygen supply would have continued the run longer than the Negroes, but the latter utilized the "oxygen debt" to a greater extent and thus were able to run longer.

The highest *R. Q.* attained by the Negro sharecroppers in the run increased with advancing age, the mean for the youngest boys being 1.06 as compared with 1.25 in Group N V (Table 3). A similar trend with age was found in the Boston whites of this age range. Table 3 reveals that the white sharecroppers and the Indiana students attained

TABLE 3

Performance in maximal work

(Mean values for each group are given)

GROUP	DURATION OF RUN (*minutes*)	APPARENT *R.Q.*	RESPIRATORY RATE	LUNG VENTILATION* (*l/min.*)	(TIDAL AIR × 100) ÷ (VITAL CAPACITY)
		A. Negro sharecroppers			
N II A	4.8	1.06	67	53	43
N II B	4.3	1.15	58	61	46
N III	4.5	1.14	54	75	49
N IV	4.3	1.20	47	83	52
N V	3.9	1.25	51	103	50
		B. White sharecroppers			
WS	4.0	1.23	37	94	50
		C. White students, Indiana University			
W IV Ind.	4.4	1.23	45	107	47
W V Ind.	4.4	1.23	38	104	50
		D. Whites in Boston			
W II B	4.9	1.12	57	53	44
W III B	3.2	1.12	50	92	52
W IV B	3.8	1.11	46	121	56
W V B	4.5	1.21	43	118	56

* Volumes at 37° C., 760 mm. Hg and saturated with water vapor.

R. Q. values of the same order of magnitude as the adult Negroes. As pointed out in the Boston study, the fact that the *R. Q.* exceeds unity in this type of work is related to the accumulation during work of lactic acid, which displaces CO_2 from the body fluids (Table 4).

TABLE 4

Blood lactate and blood sugar

(The mean concentrations are given in mg. per cent for each group)

GROUP	BLOOD LACTATE			BLOOD SUGAR		
	Rest	Work		Rest	Work	
		Moderate	*Maximal*		*Moderate*	*Maximal*
			A. Negro sharecroppers			
N II A	16	28	66	117	123	137
N II B	18	25	75	123	129	146
N III	16	23	86	124	128	153
N IV	18	27	102	114	116	145
N V	18	28	118	108	111	152
			B. White sharecroppers			
WS	15	27	113	110	122	163
			C. Whites in Boston			
W II B	11	21	51	94	101	128
W III B	11	19	62	107	110	138
W IV B	10	17	66	102	109	144
W V B	9	15	89	99	107	149

In the 50 Negro sharecroppers who performed the run the correlation between *R. Q.* and blood lactate was 0.74 ± 0.04, while in 58 whites 16 to 24 years of age it was 0.67 ± 0.05.

When the maximal lung ventilation attained by the individuals during the run is related to body weight, the group means decline rapidly with age from Group N II A to N IV in the Negroes (Table 3). The boys of Groups N II A and N II B combined attained an average of 1.81 liters per kg. of body weight per minute as compared with 1.78 in the corresponding boys in Boston. Variations among the individuals as well as among the group means were so great that the differences between the corresponding group means of the two races are insignificant. The grand average of all Negro sharecroppers is 1.67 with variations from

1.11 to 2.13 as compared with an average of 1.70 for all the Boston whites between 8 and 29 years of age where the variations ranged from 1.39 to 2.11. Groups IV and V of the Negroes with averages of 1.52 and 1.62 were close to white students at Bloomington, whose averages were 1.57 and 1.58 respectively. The lowest mean value of any group is that of 1.45 for the white sharecroppers. In general we may conclude that, even though the Negroes' vital capacities were significantly lower than those of whites of corresponding ages, the Negroes are quite as capable of ventilating the lungs in the exhausting work as are the whites.

Adequate lung ventilation in the Negroes was brought about by significantly higher respiratory rates than in the whites (Table 3). A number of the younger boys breathed faster than 70 times a minute during the run. Two boys 9 and 10 years of age had respiratory rates of 84 and 85 per minute, respectively, during the last part of the run. The highest individual rate observed in a Boston white boy of comparable age was 68 in a 10-year-old boy. The average respiratory rate of all the Boston whites between 8 and 29 years of age was 49 as compared with 55 for all the Negroes. Groups IV and V of the Negroes, with averages of 47 and 51, were higher than any of the groups of whites of corresponding ages, including Groups IV and V of the Boston study with averages of 46 and 43 and the white sharecroppers with 37.

The younger boys had relatively higher respiratory rates than the adults and therefore tended to use a smaller fraction of the vital capacity as tidal air (Table 3). This relation was observed also in the Boston study of northern whites. Of the various groups of older subjects of this study, both Negroes and whites, the average values of the ratio $\frac{\text{Tidal air} \times 100}{\text{Vital capacity}}$ were all very close to 50. The mean of that ratio among young adults in the Boston study was 56.0, which was moderately higher than in the adult sharecroppers (Table 3).

ALVEOLAR AIR

Fig. 4 presents the group means of the partial pressures of O_2 and CO_2 (pO_2 and pCO_2) in alveolar air collected from the Negroes during rest and during each of the two work experiments. Corresponding with their tendency toward greater lung ventilation during work, the younger Negro sharecroppers had higher mean values of pO_2 and lower values of pCO_2 than the older subjects. This was also true of the Boston white subjects but to a lesser degree.

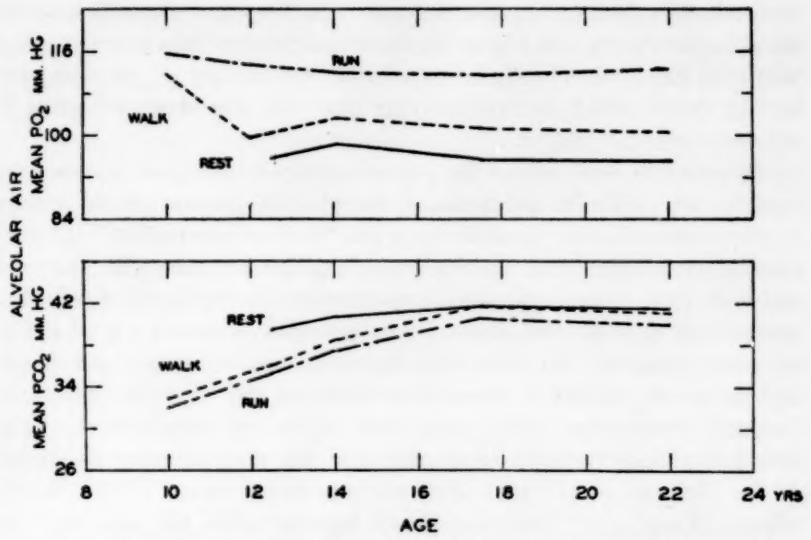

FIG. 4. THE PARTIAL PRESSURES OF O_2 AND CO_2 IN ALVEOLAR AIR OF NEGRO SHARECROPPERS AT REST, DURING MODERATE WORK, AND DURING MAXIMAL WORK

Among the older Negroes of Groups N IV and N V, the pCO_2 both at rest and during the walk was like that of whites: all values were between 35 and 55 mm. Hg. with means between 41 and 42. During the run the means were 40.6 and 40.1 respectively with a somewhat wider range from 32.5 to 58.9. The high individual values of 55 and 58.9 for the walk and the run are extraordinary and were found in a 24-year-old Negro (said to have Indian blood) whose resting alveolar pCO_2 of 48.8 was higher than any other resting value observed. This man, it will be noted, experienced increases in alveolar pCO_2 from rest to the walk and from the walk to the run.

BLOOD LACTIC ACID AND SUGAR

Mean blood lactates for the groups of Negroes during the walk were moderately higher than corresponding values reported on the Boston whites (Table 4). No variation was found that could be related to advancing age in Negroes while there was a moderate trend downward with advancing age in the groups of Boston whites in this age range. The white sharecroppers had a mean lactate in the walk of 27 mg. per

cent, which is close to the mean values of the Negroes. Since the resting blood lactates were also higher in the sharecroppers than corresponding values in the Boston study, we find that the amount of increase over resting values which occurred during the walk was about the same in the two series of subjects.

In maximal work where the rate of energy expenditure exceeds the capacity for oxidative processes, a considerable portion of the energy supplied anaerobically depends upon the "lactacid mechanism" for contracting an oxygen debt, an expression applied by Margaria, Edwards and Dill (7). The lactic acid concentration in the blood usually has reached its highest level about 5 minutes after severe work of a few minutes' duration. At this time, therefore, venous blood was drawn and its lactate content is assumed to measure the extent to which the "lactacid mechanism" is brought into action in severe work. The averages of lactic acid in blood after the run were consistently higher in the Negroes of all ages than corresponding means in the Boston whites (Table 4). This, considered together with the fact that the Negroes commonly had lower maximal capacities for supplying O_2, indicates that the superiority of the Negroes over the Boston whites in sustaining the run depended on the accumulation of a greater oxygen debt, which was due largely to a willingness to extend themselves. Possibly efficiency in running may have played a part. The white sharecroppers, with a mean blood lactate of 113 after the run, were also significantly higher than the Boston group. In the Indiana students we found means of 127 and 123 mg. per cent which are higher than in the older groups of sharecroppers. It is interesting to note that there is one factor which distinguishes all of the subjects who willingly ran up higher blood lactates from the Boston subjects—they all work hard for a living. The 39 Indiana students were to a large extent working their way through college; some were entirely self-supporting. In contrast, Groups III and IV of the Boston study were from a private school in Cambridge and most of Group V were students in Harvard College or the Harvard Business School. The Boston Group II was made up of boys from an orphanage and they were as good as the younger Negroes in performance. While environmental influence plays a part in performance in these studies, as it undoubtedly does in athletic achievement in general, the factor of race is also notable.

Blood sugar values during the walk (Table 4) were in general higher in the Negroes than in the Boston whites of corresponding ages,

the average of all Negro sharecroppers being 119.8 mg. per cent as compared with 106.8 in all the whites between 8 and 29 years of age. These were only moderately higher than the respective mean values of 115.6 and 100.6 at rest. It is possible that higher values in the small Negro boys may have been associated with excitement. The older Negroes came to the laboratory twice; they were not so excitable and their blood sugar values were not as high as those of the younger Negroes.

Blood sugar 5 minutes after the run was also higher in the Negro Groups II A, II B, and III than in the Boston boys of the same ages (Table 4). The older Negroes had essentially the same averages as the corresponding Boston groups, while the white sharecroppers were moderately higher. The greater freedom with which the younger Negro boys released sugar from the liver after the run may be related to emotional glycogenolysis, as was suggested above in connection with the walk.

SUMMARY

The two races both exhibited the following changes which are related to advancing age from 8 to 24 years: (1) Downward trends of heart rate and O_2 requirement in moderate work and of lung ventilation and respiration in both moderate and maximal work, the decline in the last two being more pronounced in Negroes than in whites. (2) Upward trends of blood lactate and *R. Q.* in exhausting work and of vital capacity in rest.

In moderate work the Negro sharecroppers in comparison with northern whites showed greater average anticipatory increases in heart rate before work and stabilized at lower levels during work. Generally they attained higher maximal rates in exhausting work than northern whites. In recovery and acceleration the races were similar.

In moderate work Negro sharecroppers between 8 and 24 years of age were more efficient than northern Negroes and whites. The *R. Q.* values in this work indicate that in this age range subjects of both races metabolized about the same proportions of fat and carbohydrate. Blood lactate was about the same, but the younger Negro boys tended to have moderately higher blood sugar values than the whites. Lung ventilation was about the same, but respiratory rates were significantly higher in the Negroes.

In maximal work the whites were able to consume a little more oxygen per minute. There is a negative correlation between the ability to consume oxygen and maximal heart rate. Working people, both Negroes and whites, were likely to accumulate a greater oxygen debt than people of higher financial rating, and were therefore likely to run for longer periods of time. Whites breathed more slowly and thus used a larger fraction of the vital capacity as tidal air, even though the Negroes had much lower vital capacities.

Alveolar CO_2 values both at rest and in work were quite similar in Negroes and whites and among adults there was little change during work from resting values.

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THE OUTCOME OF 1556 CONCEPTIONS
A MEDICAL AND SOCIOLOGICAL STUDY

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WOMEN differ in their reaction to maternity. The differences may be classified as either inherent in the genetic constitution, or dependent upon environment. The latter grouping has more practical social importance because it is more readily amenable to study and corrective influence.

The number of children in a family and their spacing largely depend on social, cultural and economic factors. In a previous paper,[2] 10,609 conceptions and their termination by viable births, induced abortions, or so-called spontaneous abortions were studied from many angles. The group then under consideration consisted of 4500 women. Similar studies in population groups of different social and economic standing seemed necessary in order to draw more accurate conclusions. Consequently, the present investigation was undertaken.

SOURCE AND CHARACTER OF MATERIAL

The data here included were obtained from clinical case histories taken by the author between 1929 and 1938 inclusive. They were ambulatory patients, seen in the course of obstetrical or gynecologic consultations. One thousand consecutive case histories were originally taken, but because of lack of pertinent data, twenty-one cases had to be discarded. In the course of the investigation the scope of the work was extended and ninety-four clinical histories were added to the material.

[1]The author is grateful for the valuable assistance of William S. Goldfarb, M.S., in the compilation of the data and preparation of the graphs.

[2] Endre K. Brunner, M.D., and Louis Newton, M.D. Abortions in relation to viable births in 10,609 pregnancies. *American Journal of Obstetrics and Gynecology*, Vol. 38, No. 1, pages 82-90, July, 1939.

This fact explains why some figures are based on 979 patients, while others are based on 1073.

All patients were seen more than once. The follow-up, in most instances, covered a period of years. The data used include the total experience, unless otherwise stated.

Since clinical histories of patients, not always healthy normal women, were studied, it will make for a clearer visualization of the group to record that at time of first consultation 24 per cent of the group had irregularity of menses, 15 per cent complained of abdominal pain, 13 per cent were pregnant, 11 per cent had leucorrhoeal discharge, and 10 per cent backache. The diagnoses were displacement, pregnancies, cervicitis and fibroids, each about 10 per cent. Pelvic infections capable of producing sterility amounted to 5.6 per cent. Forty-seven other and different conditions, mostly not affecting fertility, comprised the balance of the total diagnoses.

The following definitions of terms are repeated from the previous article. These same definitions are used in the present study.

Viable birth. When pregnancy is carried for twenty-six weeks or more, it is considered a viable birth. All premature deliveries and stillbirths are included.

Spontaneous abortion. For lack of more exact terminology, where the existing cause of abortions is vague, unknown, or not directly due to willful interference, they are classified as spontaneous.

Induced abortion. Abortions which are caused by instrumentation or toxic medications of hormonal or oxytocic nature are referred to as induced. Included in the medicated group are only those in which pregnancy was without a doubt proved.

CRUDE FIGURES

Nine hundred and seventy-nine women in the present study had a total of 1556 pregnancies, of which 869 terminated in viable births, 212 in spontaneous and 475 in induced abortions. Otherwise expressed, 55.8 per cent of all conceptions reached viability, 13.6 per cent ended in spontaneous and 30.5 per cent in induced abortions.

Six hundred and thirty-six out of 979 women experienced pregnancy —or 65 per cent. Those never pregnant totaled 35 per cent.

Considering only the parous group, the average number of pregnancies was 2.4 per patient, and an average of 1.4 viable births per parous woman.

Of the parous patients, 406, or 63.8 per cent, experienced at least one abortion, spontaneous or induced—1.7 abortions for each woman.

COLLATERAL INFLUENCES

There are many factors which influence the outcome of pregnancy, some dependent upon the will of the patient, some beyond her control. These collateral influences were studied in detail.

In order to make clear in the mind of the reader just what social and economic group was studied, the following information is here recorded.

Eighty per cent of the women lived in Greater New York, 40 per cent of them in Manhattan, 14 per cent in Queens, 12 per cent in Brooklyn, 12 per cent in Bronx, and 1 per cent in Richmond. Two thirds of the remaining 20 per cent lived in the suburbs, and one third were scattered in distant points.

Eighty-four per cent of those studied lived in apartments. Furnished rooms and hotel rooms are included in this category. An average of 2.2 persons were found to share each of these dwellings. Twenty-four per cent lived alone; in 34 per cent of the cases, two persons shared the dwelling; 13 per cent had three persons in each apartment; 8 per cent had four; 3 per cent, five.

The small number of patients (15 per cent) who lived in detached homes is no doubt due to the fact that the majority of women here considered were residents in New York City. One third of these shared the residence with only one person. One quarter of the house dwellers lived in family groups of 3; one quarter, in groups of 4. The average number of occupants was 3.1 persons.

Rent is perhaps the largest single expenditure of a family. Where a dwelling was rented by two or more wage earning women only the pro rata rent was here recorded. Where a family owned their home, no rent was estimated.

The monthly rental of 25 per cent of the group was $30.00 or less. The largest number of them, 44 per cent, paid between $30.00 and $50.00. Nineteen per cent paid rentals of from $50.00 to $70.00. The remaining families, 12 per cent, paid more.

All incomes were estimated on a weekly basis. Where a temporary unemployment was known, the amount of loss was deducted from the income. Where unemployment was over a year's duration, no income was registered.

Half of the women here considered, or 552, were gainfully employed. Fifty-four per cent earned less than $35.00 a week; 34 per cent, from $35.00–$50.00; and 12 per cent, $50.00 or over. The average weekly income was $29.30.

The incomes of 758 husbands averaged $50.50 a week. Forty-seven per cent of them earned between $25.00 and $50.00; 29 per cent, between $50.00 and $75.00; and 18 per cent, above $75.00.

Many working women had working husbands. The combined earnings of this group averaged a weekly $51.70. Since the average combined income is only slightly higher than the average income of men who were the sole support of their families, it seems indicated that the families where both man and wife worked did this in order to earn an amount necessary to maintain a certain social level and that when men earned about $50.00 a week, a majority of the wives did not seek remunerative employment.

Eighty-three per cent of the women and 73 per cent of their husbands were American born; the parents of the women were 49 per cent American born. The remainder were a cosmopolitan mixture with an unrecorded number of intermarriages between various nationalities.

Approximately half of the 1053 women studied were housewives. Twenty-five per cent were engaged in some profession. Thirteen per cent were secretaries or clerical workers. Seven per cent owned or were employed in commercial establishments.

The occupations of 765 husbands may be grouped as follows: 36 per cent in the professions; 34 per cent in business; 17 per cent technicians or skilled workmen.

Even more telling than the foregoing, as to the background of the patients and their families, is their education. The education of the entire group of women and of their husbands was known. Twenty-seven per cent of the women and 43 per cent of the men were college graduates. High school diplomas were held by 40 per cent of the women, 33 per cent of the men. Those with some college training or its equivalent in professional schools stood as follows: women, 22 per cent; men, 13 per cent. Eleven per cent of both men and women did not complete high school education.

It would be interesting to compare this education with that of parents and children to see the trend, but unfortunately the extent of the parents' education was only rarely recorded, and the children, in most instances, were young and still continued their schooling.

MARRIAGE

It is obvious that conception and birth increase with the proportion of the number of married women in the group. Seven hundred and twenty-seven, or 74.3 per cent of the patients, were married, and 252, or 25.7 per cent, were single.

Five hundred and sixty-one, or 77.2 per cent of the 727 married patients, experienced pregnancy. Four hundred and forty-five, or 61.2 per cent, had viable births. One hundred and forty-six, or 20 per cent, had at least one spontaneous and 228, or 31.4 per cent, at least one induced abortion. The remainder, 166, or 22.8 per cent married women, who had no conceptions, can be divided into two groups: 68 women, or 9.0 per cent, who complained of sterility, and 98 women, or 13.0 per cent, who either successfully prevented conception or were infertile but credited their contraceptive method with success. See Table 1.

TABLE 1

Total pregnancy record

(727, or 74.3, were married: 252, or 25.7, were single.)

	Number of patients		PAROUS			NON-PAROUS			
			Viable	Spontaneous abortion	Induced abortion	Number of patients	Sexually inexperienced	Infertile	Contraception successful
Married	727	No.	445	146	228	166	0	68	98
		Per cent	61.2	20	31.4	22.8	0	9	13
Single	252	No.	5	6	66	177	86	..	91
		Per cent	1.9	2.3	26	70.2	34	..	36.1

One hundred and seventy-seven, or 70.2 per cent of the 252 single women, experienced no pregnancy; five, or 1.9 per cent, had viable births; six, or 2.3 per cent, had spontaneous and sixty-six, or 26 per

cent, had induced abortions. This single group, however, should not be measured by the same yardstick as the married group, because they are younger, their sex life less settled and because they also include a group of sexually inexperienced. This latter group included seventy women, or 27.8 per cent, having intact hymen; and sixteen, or 6.3 per cent, in whom, although the hymen was dilated, coitus never took place. Otherwise stated, eighty-six, or 34.0 per cent of the single group, apparently never had intercourse, and ninety-one, or 51.4 per cent of 177 nulligravida, successfully controlled pregnancy or were infertile.

Very different figures will be obtained if the conception record for the single group is figured only for those women whose sex life differed from the married group by the fact of marriage alone. One hundred and sixty-six, or 65.9 per cent of the single women, belonged to this group. Only five women, or 3.0 per cent, carried their pregnancies to viability. Six, or 3.6 per cent, aborted spontaneously, and sixty-six, or 39.7 per cent, had at least one induced abortion. See Table 2.

TABLE 2

Pregnancy record of single women with sex experience

	NUMBER	PERCENT
Viable births	5	3.0
Spontaneous abortions	6	3.6
Induced abortions	66	39.7
Successful contraception	91	54.1
TOTAL	166	....

The number of pregnancies is still considerably lower than in the married patients. This might have several explanations—a relative infertility of the younger women, the more restricted opportunity for sex practice, and finally more care in contraceptive technique. The last reason has mathematical proof when a comparison is made between the successful users of contraception in the married and the single groups, 13.0 per cent and 54.1 per cent respectively, as shown in Tables 1 and 2.

Ninety-nine pregnancies accredited to married women occurred prior to their marriage, and consequently should be classified as pre- or extra-

marital pregnancies. This group, together with the pregnancies which occurred in single women, comprise a total of 176 pregnancies.

TABLE 3

Termination of intra- and extra-marital conceptions

	INTRA-MARITAL CONCEPTION		EXTRA-MARITAL CONCEPTION		TOTALS	
	Number	Percent	Number	Percent	Number	Percent
Viable births.....	837	60.7	32	18.1	869	55.9
Spontaneous abortions..	188	13.6	24	13.6	212	13.6
Induced abortions.....	355	25.7	120	68.9	475	30.5
TOTALS.....	1380	...	176	...	1556	...

The termination of all conceptions is shown in Table 3. The difference in the percentage of induced abortions in the unmarried group over the same figures in the married group is not surprising. The fact that the incidence of spontaneous abortion in both married and unmarried women is identical stands out challengingly.

STATE AND CHURCH

It was emphasized in the paper already alluded to, that the church and state take very positive interest in the question of pregnancy. There may be some variation in the reaction of some states or faiths as to the admissible or permitted methods of contraception; there is, however, a definite uniformity in the strict censure of abortion. Since these patients are all under similar secular influences, the variations which affect their reactions towards pregnancy or its control, either by means of prevention before or after conception, may depend on their religious background; hence, as in the previous paper, the main figures will be expressed separately for the three major religious groups—the Catholics, Protestants, and Jews.

Four hundred and five women out of a total of 979, or 41 per cent, were Catholics; 328, or 33 per cent, were Protestants; and 246, or 25 per cent, Jewish.

Fig. 1 shows the outcome of 1556 pregnancies. Only the married group is recorded according to their religious affiliation.

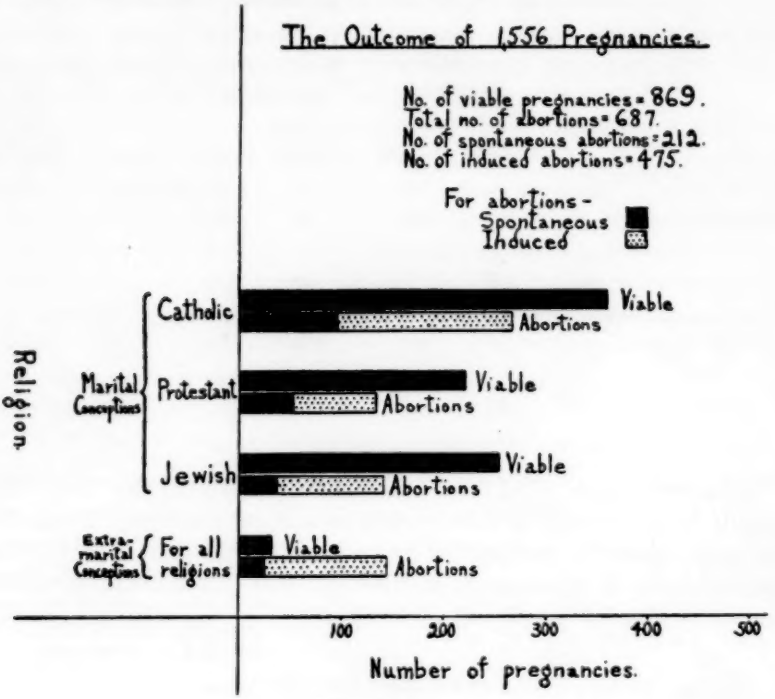

FIGURE 1

Table 4 shows that 304 Catholic women had 628 conceptions, out of which 361 resulted in viable births; ninety-seven, or 15.4 per cent, in spontaneous and 170, or 27.1 per cent, in induced abortions. Two hundred and twenty-one Protestant women had 356 conceptions with 221 viable births; fifty-three, or 14.9 per cent, spontaneous and eighty-two, or 23.0 per cent, induced abortions. Two hundred and two Jewish women had a total of 396 conceptions resulting in 255 viable births; thirty-eight, or 9.6 per cent, spontaneous and 103, or 26 per cent, induced abortions.

It is seen that an average of 1.2 children was born to the above group of women: to the Catholics, 1.2; to the Protestants, 1.0; to the Jews, 1.3.

TABLE 4

Termination of 1380 pregnancies in 727 married women, grouped according to religious affiliation

		VIABLE BIRTH	SPONTANEOUS ABORTION	INDUCED ABORTION	TOTAL CONCEPTIONS
Catholics (304)	No.	361	97	170	628
	Per cent	57.5	15.4	27.1	100
Protestants (221)	No.	221	53	82	356
	Per cent	62.1	14.9	23.0	100
Jews (202)	No.	255	38	103	396
	Per cent	64.4	9.6	26.0	100

TABLE 5

Age at first visit

		20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	TOTALS
Parous Catholics	No.	43	83	76	43	17	13	9	3	1	4	292
	Per cent	14.8	28.4	26.0	14.8	5.8	4.5	3.0	1.0	0.4	1.4	100.1
Parous Protestants	No.	22	48	42	18	18	9	13	6	5	2	189
	Per cent	12.0	26.7	23.0	9.8	9.8	4.9	7.1	3.3	2.6	1.0	100.0
Parous Jews	No.	15	52	32	21	17	15	6	2	1	0	161
	Per cent	9.3	32.3	19.9	13.0	10.6	9.3	3.7	1.2	0.6	..	99.9
Non-parous patients	No.	107	103	58	37	24	5	5	4	0	0	343
	Per cent	31.2	30.0	16.9	10.8	7.0	1.5	1.5	1.1	..	..	100.0
TOTALS	No.	187	286	208	119	76	42	33	15	7	6	979
	Per cent	19.1	29.2	21.1	12.2	7.8	4.3	3.4	1.5	0.7	0.6	99.9

Average age of parous Catholics — 32.4 years.
Average age of parous Protestants — 35.0 years.
Average age of parous Jews — 33.8 years.
Average age of non-parous patients — 29.2 years.

AGE DATA

Age at first visit. The older the group under consideration, the larger will be the pregnancy yield. The younger the group, the more is the likelihood for future children. Obviously, then, it is essential to show the age distribution of the cases here considered. See Table 5.

Age at marriage. Table 6 shows that well above 90 per cent of women, regardless of religion, married below the age of thirty. The average age for the Catholic women was 23.6 years; that for the Protestants, 25.2; and for the Jews, 23.3. Considering the whole group, the average age at marriage was 24.0 years.

TABLE 6

Age at marriage

		UP TO 20	21-25	26-30	31-35	36-40	40 PLUS	TOTALS
Catholics	No.	76	134	69	14	3	1	297
	Per cent	25.6	45.1	23.2	4.8	1.0	0.3	
Protestants	No.	39	85	52	10	3	1	190
	Per cent	20.5	44.7	27.4	5.3	1.6	0.5	
Jewish	No.	47	114	28	4	1	1	194
	Per cent	24.2	58.7	14.4	2.1	0.5	0.5	
								681

Taking the average of the children born by the arbitrary age of thirty, we arrive at the figure of 1.0 child for each woman. The Catholics had 1.0; the Protestants, 1.2; and the Jewish women, 0.9.

ABORTIONS

Gestation month of abortions. There were a total of 212 spontaneous abortions, one hundred of which occurred during the second lunar month and sixty-three during the third. The rest were equally divided between all other months.

Twenty-five of the 475 induced abortions were terminated in the first lunar month, 353 in the second, seventy-four in the third, eleven

in the fourth, ten in the fifth, and two in the sixth lunar month of pregnancy.

Abortion in relation to age. The largest number of the abortions, both spontaneous and induced, occurred in women between twenty-six and thirty years of age.

Although there were few conceptions below the age of twenty-one, more than 20 per cent of those aborted spontaneously in all groups.

A relative infertility of the adolescents may account for both the small number of conceptions and the large percentage of spontaneous abortions. Between the ages of twenty-one and thirty-five an average of 12.0 per cent of all conceptions ended in spontaneous abortion, with

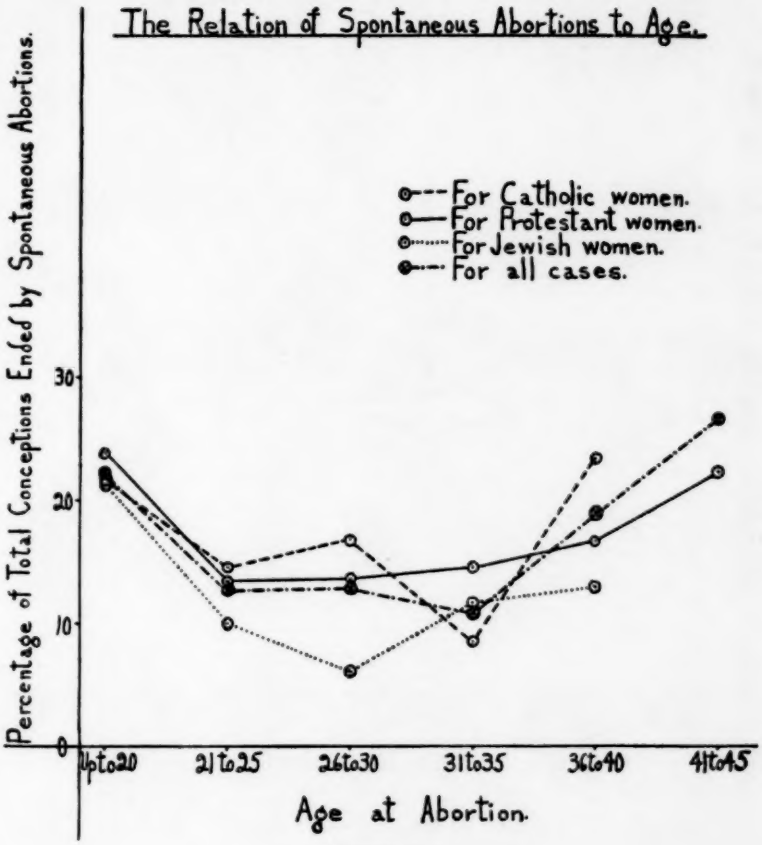

FIGURE 2

the Jewish group lower and the Catholic group higher. After the age of thirty-five, the percentage of spontaneous abortions jumped to 20+ per cent, probably because pelvic pathology develops in the wake of pregnancies and tumor formations. See Fig. 2.

There seems to be a definite relationship between the age of patients and the desire to terminate pregnancy. Fig. 3 shows that with advanc-

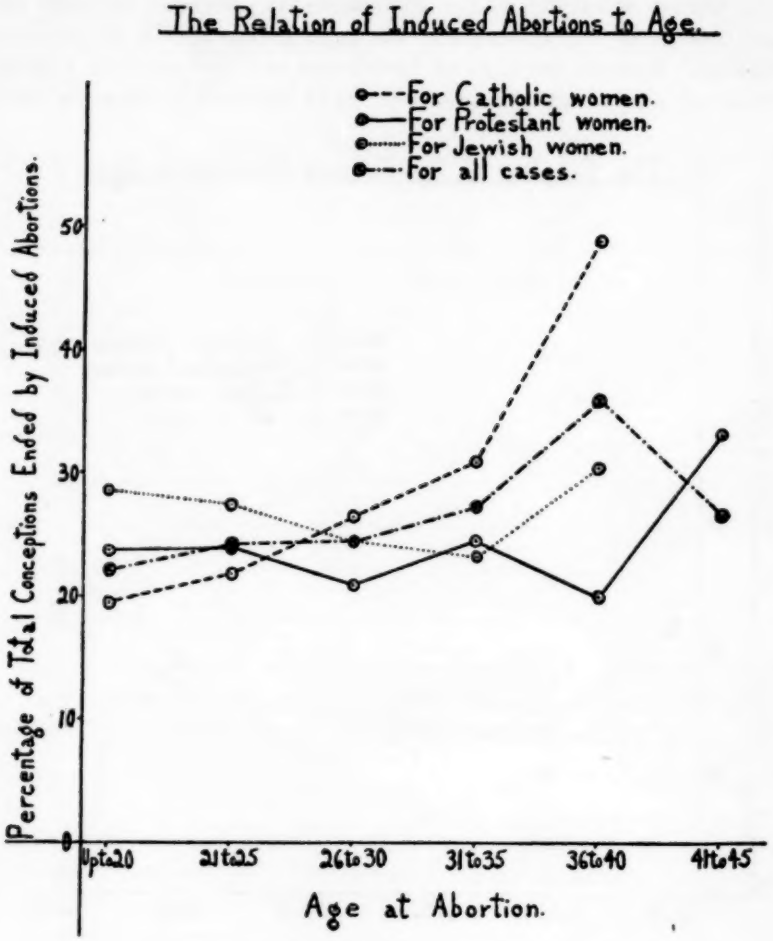

FIGURE 3

TABLE 7

Termination of 1364 pregnancies in relation to years married

NUMBER OF YEARS MARRIED		4 OR LESS	5-9	10-14	15-19	20-24	25-29
Viable births							
Catholics	No.	196	102	42	14	2	0
(356 pregnancies)	Per cent	59.7	56.1	58.3	53.8	33.3	0.0
Protestants	No.	119	67	22	5	7	1
(221 pregnancies)	Per cent	60.4	74.4	64.7	38.4	100.0	100.0
Jews	No.	139	75	32	9	0	0
(255 pregnancies)	Per cent	65.3	75.6	66.7	60.0	0.0	0.0
Totals	No.	454	244	96	28	9	1
(832)	Per cent	61.5	60.4	62.3	51.9	69.2	100.0
Spontaneous abortions							
Catholics	No.	54	29	8	2	1	0
(94 spont. abort.)	Per cent	16.5	15.9	11.1	7.7	16.7	0.0
Protestants	No.	28	16	4	5	0	0
(53 spont. abort.)	Per cent	14.2	15.4	11.8	38.5	0.0	0.0
Jews	No.	22	9	4	3	0	0
(38 spont. abort.)	Per cent	10.3	7.6	8.3	20.0	0.0	0.0
Totals	No.	104	54	16	10	1	0
(185)	Per cent	14.1	13.4	10.4	18.5	7.7	0.0
Induced abortions							
Catholics	No.	78	51	22	10	3	0
(164 induced abort.)	Per cent	23.8	28.0	30.6	38.5	50.0	0.0
Protestants	No.	50	21	8	3	0	0
(82 induced abort.)	Per cent	25.4	20.2	23.5	23.1	0.0	0.0
Jews	No.	52	34	12	3	0	0
(101 induced abort.)	Per cent	24.4	28.8	25.0	20.0	0.0	0.0
Totals	No.	180	106	42	16	3	0
(347)	Per cent	24.4	26.2	27.3	29.6	23.1	0.0

ing age of the women a larger percentage of the total conceptions are terminated artificially.

Next, the relation of years married to abortion, according to religious affiliation, was examined. It seems that the percentage of spontaneous abortions in the first fifteen years of marriage ran about 15 per cent in the Catholic, 14 per cent in the Protestant, and 10 per cent in the Jewish group, after which the percentage rose in all groups. The curve would be similar to the ones in Figs. 2 and 3 in which the relation of age to abortions was studied. The explanation of the rise in percentage of spontaneous abortion above fifteen years of marriage is probably the development of pelvic pathology. No good explanation was found to account for the consistently lower percentage of spontaneous abortions in the Jewish women.

While the percentage of induced abortion steadily rose with the number of years married in the Catholic women, from an initial 24 per cent to 50 per cent, the Protestant group dropped from an initial 26 per cent to 20 per cent, and never rose again above 23 per cent. The Jewish group started at 24 per cent, had an initial rise to 28 per cent, but then gradually dropped to 20 per cent. See Table 7.

There was a definite similarity between the Protestant and Jewish groups, in the incidence of induced abortions, but the Catholic women reacted differently. The explanations of this fact lie beyond the scope of this paper.

Order of conceptions in relation to termination. From the foregoing it is known how many conceptions were carried to viability and how many were wasted in abortions in a population group here defined as specifically as was possible. It would be pertinent to know if the wastage was haphazard or whether it followed some pattern. It may be said of all the conceptions which occurred in wedlock that about 65 per cent of the first two pregnancies were carried to viability, 14 per cent were lost by spontaneous abortion, and 20 per cent were artificially interrupted. Only 58 per cent of the second two conceptions were carried to viability, 11 per cent were lost by spontaneous abortion, and 31 per cent were aborted by induction. Only 42 per cent of the fifth conceptions were carried to viability, 17 per cent ended in spontaneous abortion, and 38 per cent in wilful abortion. See Fig. 4.

Methods of Induction. It is natural next to examine the methods of interruption and to tabulate who was responsible in carrying out the technique. See Table 8.

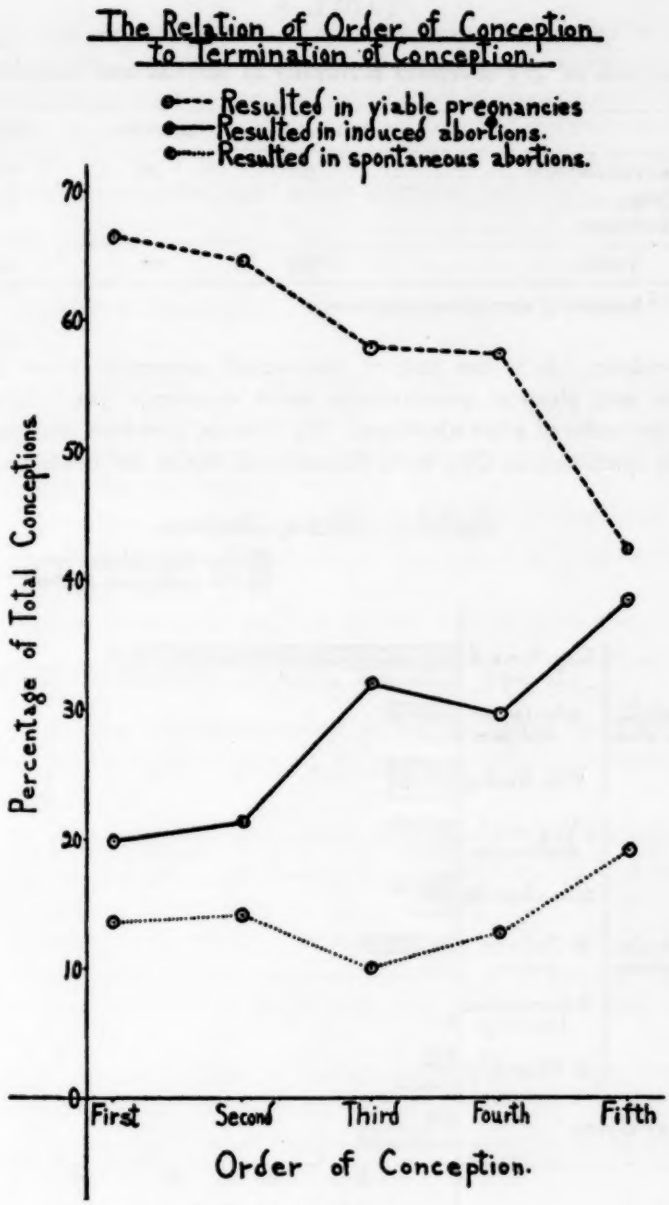
The Relation of Order of Conception to Termination of Conception.
Resulted in viable pregnancies
Resulted in induced abortions.
Resulted in spontaneous abortions.
Percentage of Total Conceptions
70
60
50
40
30
20
10
0
First
Second
Third
Fourth
Fifth
Order of Conception.

FIGURE 4

TABLE 8

Induction of 475 abortions according to method and technician

	PHYSICIAN	MIDWIFE	SELF
Instrumentation	371*	50	11
Drugs	6	..	34
Hormones	6	..	..
Totals	383	50	45

* Includes 5 therapeutic abortions.

Morbidity. It is not easy to reconstruct accurately from clinical histories and physical examinations made sometimes years later, the morbidity suffered after abortions. An attempt, however, was made to tabulate symptoms as they were remembered, under the headings, "Im-

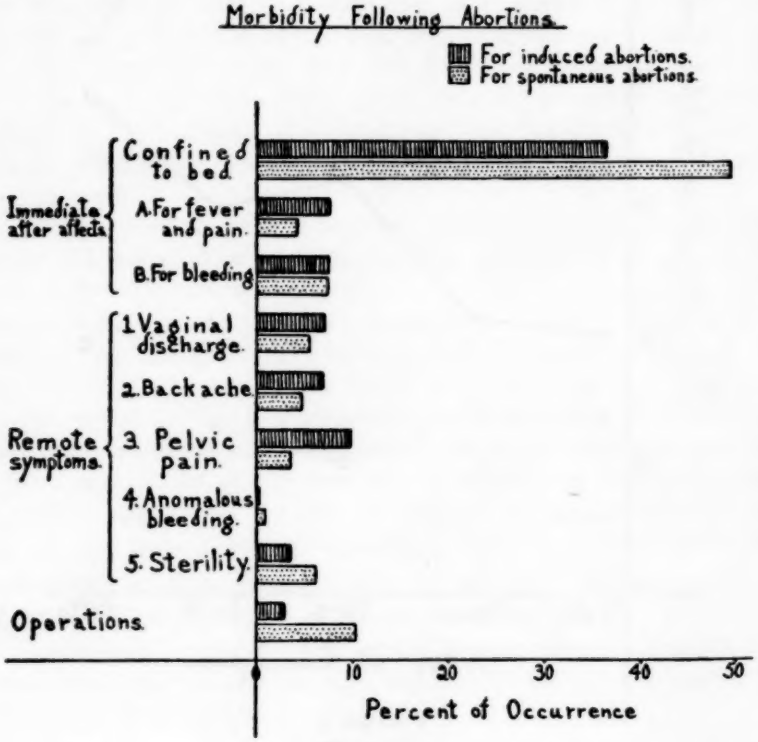

FIGURE 5

mediate after-effect," which includes confinement to bed and the reason for it, and "Remote after-effect," listing gynecologic symptoms which started following abortions and were confirmed by physical examinations. Operations were included only when they followed the abortion within an arbitrary period of six weeks, and were done explicitly to overcome the immediate after-effects of a recent abortion. See Fig. 5.

SUMMARY

1. The clinical histories of 1073 women are here studied as to their background:

a. 80 per cent lived in Greater New York.

b. 84 per cent lived in apartments.

c. 44 per cent of them paid between $30.00 and $50.00 rent per month; the rest, more.

d. The average income of the families was $51.70 per week.

e. 83 per cent of the women and 73 per cent of their husbands were American born.

f. Half of the women were housewives, half of them wage earners.

g. 27 per cent were college graduates; 22 per cent had some college training; 67 per cent completed high school educations.

h. 74 per cent were married—at an average age of 24.

i. 41 per cent were Catholics, 33 per cent Protestants, and 25 per cent Jewish.

2. Of these 1073 women, 979 are studied as to their pregnancies.

a. 979 women had 1556 conceptions, of which 869, or 55.8 per cent, reached viability; 212, or 13.6 per cent, ended in spontaneous abortion; 475, or 30.5 per cent, ended in induced abortion.

b. 65 per cent of the group experienced pregnancy; the average number of pregnancies per individual was 2.4 per cent, half of which reached viability.

c. 63.8 per cent of the parous group had at least one abortion—spontaneous or induced—the average being 1.7.

3. How age, marriage, and religious affiliation affect the figures given in point 2 is shown by tables and figures.

4. The largest number of abortions, both spontaneous and induced, occurred during the second month of gestation.

5. The first two pregnanices were most apt to be carried to term; with each subsequent conception the chances as to survival were sharply reduced.

6. The overwhelming number of induced abortions were done by physicians and by means of instruments.

DERMATOGLYPHICS IN NORTH AMERICAN INDIANS AND SPANISH-AMERICANS*

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THIS note records the dermatoglyphic characteristics, including finger-tips, palms and soles, in three groups of North American Indians (Navajo, Pueblo, Hopi) and in New Mexicans of Spanish descent (hereafter designated Spanish-Americans). In view of the prospect of an eventual account of broad racial comparisons, the present comparative references are confined largely to resemblances and differences of the groups under consideration. There are no published observations on Spanish-Americans, while the North American Indians are represented only by Downey's ('27) record of finger prints in fifty Arapaho, the report of Cummins and Goldstein ('32) on finger prints and palmar dermatoglyphics in seventy-nine Comanche, and the report by Ride ('35) dealing with certain palmar features in fifty-three British Columbian Indians. The present material is an addition to the gradually enlarging data relating to dermatoglyphic variation among races, especially important in that the plantar features of North American Indians are made available for the first time.

The material was collected in the schools of several New Mexican villages, the subjects being children whose ages are mostly included within a range of eight to eleven years. The Indians were selected, on the basis of genealogical records, to secure full-blood subjects. The numbers in the Indian groups follow: Navajo, 93; Pueblo, 131; Hopi, 59. The Spanish-American series is divided according to its original sources, 110 subjects from Chamita and 97 from the Bernalillo Mission School, for the reason that the Chamita group exhibits dermatoglyphic

* The prints upon which this study is based were collected under the direction of S. D. Aberle, whose work was made financially possible by the Carnegie Institution of Washington, the Carnegie Corporation of New York, and the Bureau of Indian Affairs.

traits which are taken to be signs of Indian admixture. Excepting in the Bernalillo group, which is composed predominatingly of females, the sexes are about equally represented. In these small samples separate consideration of the sexes is hardly feasible, and likewise it seems undesirable to make the groups still smaller by the exclusion of related individuals. It must not be forgotten, however, that school populations include relatives as close as siblings, all but one of whom would be excluded in the formation of an ideal racial sample.

Methods employed in analyzing the dermatoglyphics are mentioned separately in connection with the various features to which they apply. Tabulations of data compiled in the progress of the study, too extensive for publication, are filed in the Wistar Institute of Anatomy and Biology.

OBSERVATIONS

Finger prints.—The finger prints are classified according to the four fundamental types: arches, radial loops, ulnar loops and whorls. The percentile frequencies of these types in the several groups, together with comparative figures from other relevant collections, are listed in Table 1. In the five series of North-American Indians the consistently high values of whorls are noteworthy. Special emphasis may be placed on the 50.6 per cent occurrence of these patterns in the total Indian material, 400 subjects, as compared with the lower frequencies in Middle American and South American Indians, 38.9 per cent and 37.0 per cent respectively.

Comparisons of the frequencies of pattern types may be made to advantage with the use of the index of pattern intensity (Cummins and Goldstein)[1]. The index is an integral expression of the total pattern complement of an individual or of the mean pattern complement in a group. It is simply a summation of values for arches, loops and whorls (0, 1 and 2 respectively). With the rarest of exceptions these values are identical to the number of triradii, or deltas. In individuals the indices range from zero, indicating ten arches, to the value for ten whorls, 20.

In Table 2 the mean indices of pattern intensity are arranged for ready comparison of the five series here reported. It will be noted that

[1] Kirchmair and Poll ('36) published an independently developed expression on exactly the same principle. Known as the "Deltie", their index differs only in that it is the average of the ten digital values rather than the summation.

TABLE 1

Some comparative percentile occurrences of finger-print pattern types (number of subjects in parentheses)

	ARCHES	RADIAL LOOPS	ULNAR LOOPS	WHORLS
Spanish, Oloriz.....	6.5	63.2		30.3
Spanish-Americans				
Bernalillo (93), this series.....	7.7	4.0	58.9	29.4
Chamita (110), this series.....	3.3	3.7	48.2	44.8
Indians of North America				
Navajo (93), this series.....	2.5	2.0	37.3	58.2
Pueblo (131), this series.....	6.8	3.1	37.0	53.1
Arapaho (50), Downey.....	4.6	3.6	44.2	47.6
Hopi (59), this series.....	2.9	1.5	51.5	44.1
Comanche (67), Cummins and Goldstein	6.3	1.9	48.5	43.3
Weighted average (400)....	4.9	2.5	42.0	50.6
Indians of Mexico and Middle America				
Weighted average (633), combining series of Cummins; Leche; Cummins and Steggerda.....	4.4	3.1	53.6	38.9
Indians of South America				
Chilean (246), Henckel.....	7.0	5.5	50.5	37.0

the high whorl frequencies of the Indians are reflected in indices 15.57 (Navajo), 14.64 (Pueblo), and 14.12 (Hopi). The Chamita series of Spanish-Americans has an index (14.15) identical to that of the Hopi and insignificantly lower than the Pueblo, while the Bernalillo series is significantly different not only from the three Indian populations but from the Chamita series as well. The Bernalillo group exhibits pattern frequencies typical of the Spanish (Table 1). That there must be considerable Indian admixture in the Chamita series, suggested by the finger-print pattern frequencies, is indicated by additional evidences which are presented below.

TABLE 2

Indices of pattern intensity: with their probable errors, differences and probable errors of the differences in all comparisons

	NAVAJO	PUEBLO	HOPI	SPANISH-AMERICAN (Chamita)
	15.57 ± 0.24	14.64 ± 0.26	14.12 ± 0.29	14.15 ± 0.24
Pueblo	0.93 ± 0.35	.....	.....	.....
Hopi	1.45 ± 0.38	0.52 ± 0.31	.....	.....
Spanish-American, (Chamita)	1.42 ± 0.34	0.49 ± 0.35	0.03 ± 0.38	.....
Spanish-American, (Bernalillo) ..... 12.16 ± 0.25	3.41 ± 0.35	2.48 ± 0.36	1.96 ± 0.38	1.99 ± 0.35

Tabulations of the frequencies of pattern types on individual digits (Wistar tables) disclose some traits in which all five populations conform to generic tendencies in pattern-type distribution, such as concentrations of arches and radial loops on digit 2 and whorls on digits 1 and 4. In the Indians, however, and in the Chamita series of Spanish-Americans, there occur certain distributional traits of arches and whorls which are worthy of special mention. The figures are here reduced to the dactylodiagram[2] designed by Poll ('38), the construction of which is explained in the legend.

Two noteworthy results are indicated in the dactylodiagrams, Fig. 1. (a) The form of the graph of the Bernalillo Spanish-Americans conforms in general to that of European stocks, while all three Indian

[2] At the request of the late Doctor Poll I am calling attention at this first opportunity to two corrections to be made in his 1938 paper. (a) The formulae at the top of page 81 should read in each case as the *sum* of the two square roots rather than the difference between them. (b) The scale of the dactylodiagrams drawn by Poll is not mentioned in the publication. The values of pairs and groups determined by direct measurement naturally will vary according to the scale of the graph, and it should have been stated that the values cited are distances in millimeters measured on graphs in which 1 per cent equals 2.78 mm.

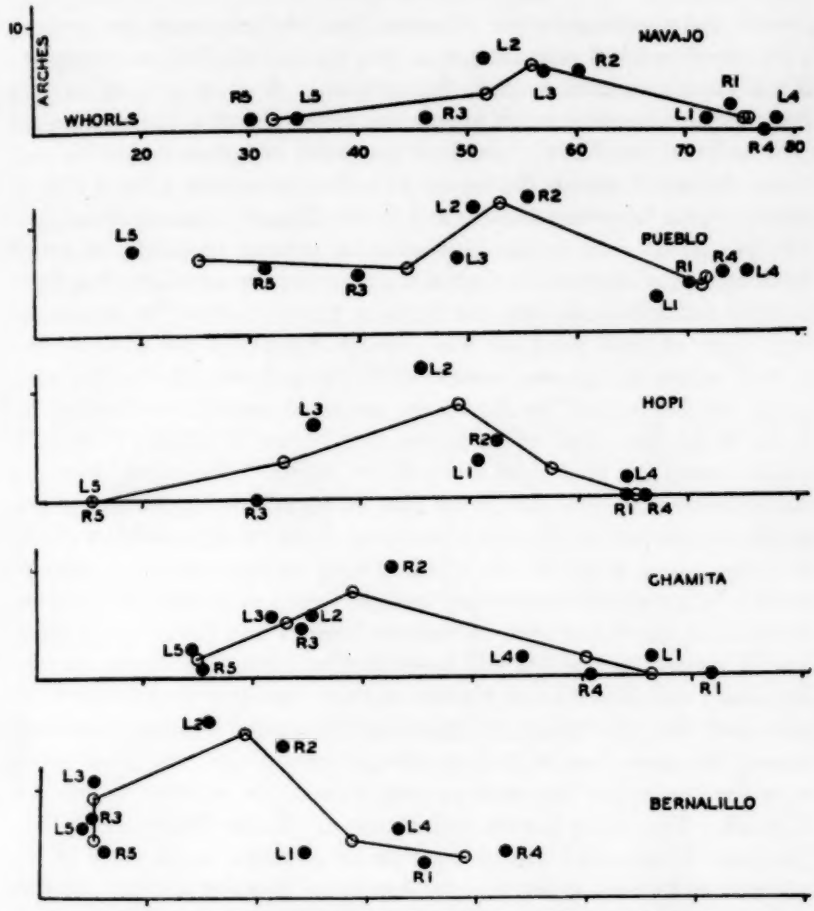

FIG. 1. DACTYLODIAGRAMS OF THE THREE SERIES OF INDIANS AND TWO SERIES OF SPANISH-AMERICANS

The dactylodiagram (Poll) is a plotting of the percentile frequencies of arches and whorls of the ten digits, whorls on the abscissa and arches on the ordinate. Individual digital values are indicated here as solid black circles, each identified by the number of the digit and initial letter of the side, right or left. The seriation of the digits is determined by the usual order of ascending frequencies of whorls: digits 5, 3, 2 and 1-4. The graph is drawn through the arithmetic means (open circles) of L5-R5, L3-R3, L2-R2, L1-L4 and R1-R4. Note that digits 5, 3 and 2 are treated as *pairs*, each *pair* being composed of corresponding digits on opposite hands, while digits 1 and 4 of each hand are treated as a *group*. The combinations in pairs and groups conform to the relationships of arch and whorl frequencies which prevail in most of the populations which have been studied with respect to these points, though as noted in the text the Indian series and the Chamita sample of Spanish-Americans represent an exceptional situation.

groups, and significantly the Chamita Spanish-Americans too, present a depressed and less compact graph of a type which Poll in correspondence was accustomed to term "mongoloid". It is of interest to note that this conformation holds also in the other reported Indian material (not only on the North American continent but also in Middle and South America) and in Eskimos. (b) The pair-group rule of Poll is void in North American Indians and in the Chamita Spanish-Americans. The pair-group rule is that expression of pattern symmetry in which the frequencies of arches and whorls are similar on corresponding digits of right and left hands only for digits 2, 3 and 5, while the thumb and ring finger of each hand are more closely related to one another than to their mates of opposite hands. Poll has pointed out that the pair-group rule holds in all the European peoples studied in this connection, in the Mongolian races, in the known populations of Asiatic Turkey, in Rwala Arabs and in peoples of northern Africa. He shows, however, that exceptions to this pair-group rule do occur, leading to a condition designated the rule of all pairs wherein all digits of right and left hands, including 1 and 4, are closely allied to each other as mates of opposite hands. The reported exceptions[3] include blacks of central and western Africa, also blacks and their hybrids in Jamaica and Cuba. It is therefore of interest to find (as will be evident by inspection of the dactylodiagrams) that Navajo and Pueblo similarly conform to the rule of all pairs and that the apparently hybridized Chamita Spanish-Americans present this same departure from the pair-group rule; the Hopi group is on the borderline, but perhaps only because the number of subjects is small. The other known collections of North American Indians (Arapaho, Comanche) exhibit the rule of all pairs, as do some of the reported collections from Middle America. Henckel's ('34) Chilean Indians conform to the pair-group rule. Notwithstanding the small sizes of the North American collections now available, the consistency of findings, with the doubtful exception of the Hopi, is of no little interest in validating a further exception to the pair-group rule.

Palmar patterns.—It is customary in racial analyses to formulate the configurations of the five palmar areas (hypothenar, thenar/first interdigital, and second, third and fourth interdigitals). In each of

[3] In a personal communication (March 23, 1939) Poll calls attention to his later finding of a sex differential in reference to the pair-group rule, which applies in Chinese, Japanese, and Koreans. Males of these populations follow the pair-group rule, females the rule of all pairs.

these areas the configuration may be patternless (i. e., being an "open field" in which the ridges are straight or very slightly curved in their courses) or a pattern of one or another type. It is only the total frequency of patterns in each area, combining all types, which can be considered in collections so small as these. But racial variations in total frequencies are known to exist, and the material thus affords opportunity to examine the trends distinctive of the North American Indian and to compare them with Spanish-Americans. The methods of interpretation and formulation follow Cummins *et al.* ('29).

Table 3 lists the pattern frequencies, with right and left hands combined, for all five series. The Indian material, as contrasted with the

TABLE 3

Percentile frequencies, right and left hands combined, of true patterns and marked vestiges in the five palmar areas

	HYPO-THENAR	THENAR/FIRST INTERDIGITAL	SECOND INTER-DIGITAL	THIRD INTER-DIGITAL	FOURTH INTER-DIGITAL
Navajo (93)	15.6	28.5	1.6	28.5	71.5
Hopi (59)	6.8	26.3	1.7	21.2	75.4
Pueblo (131)	13.0	21.0	1.5	20.6	79.8
Weighted average, Indians (283)	12.6	24.6	1.6	23.3	76.2
Spanish-American, Chamita (110)	26.9	17.7	5.5	45.0	69.6
Spanish-American, Bernalillo (97)	34.0	15.5	6.7	40.7	69.1
Weighted average, Spanish-Americans (207)	30.2	16.7	6.1	43.0	69.4

Spanish-American, discloses traits which are not unexpected in the light of previous studies of the Comanche, Indians of Middle America and European stocks. It will be observed that the Indians present less frequent patterns in the hypothenar, second interdigital and third inter-

digital areas, while thenar/first interdigitals and fourth interdigitals are more abundant. With the numbers available, the differences among the Indian groups are not statistically significant, nor are there significant differences between the Chamita and Bernalillo Spanish-Americans. It may be noted, nevertheless, that the Chamita series deviates slightly from the Bernalillo, and toward the Indian traits in the instance of hypothenar, thenar/first interdigital and second interdigital patterns; the difference of third interdigital pattern frequencies, in the opposite direction, is again statistically insignificant.

Bimanual differences in the incidence of patterns (Wistar tables) are in agreement with the usual excess in right hands of hypothenars, second and third interdigitals, with the lefts bearing greater numbers of thenar/first interdigitals and fourth interdigitals. In the twenty-five bimanual comparisons (five patterns in each of five groups) there are but two exceptions to this generalization, both involving the hypothenar pattern. In the Chamita group its frequencies are 25.5 per cent and 28.2 per cent for right and left hands respectively, while in the Bernalillo series right and left hands bear equal numbers of hypothenar patterns, 34 per cent.

Palmar main lines.—The palmar main lines are traced and formulated by the methods of Cummins *et al.*, and the completely tabulated determinations are included in the Wistar files.

There is no question but that the most important aspect of the main lines is their indication of the general alignment of ridges over the palm. Races vary, as do right and left hands in the one race, in the inclination of such ridge courses with reference to the longitudinal axis of the hand. In 1936 Cummins proposed a "main-line index" for statement of this palmar characteristic. The index, based upon lines A and D, is an integral value ordinarily ranging from 3 to 12 in individual hands. The sequence of increasing magnitudes of the index reflects progressively increased tendency toward transverse ridge courses.

Main-line indices of the five groups are listed in Table 4. Examining first the indications of group differences, and considering the mean indices of right and left hands combined, it will be evident that significant differences occur neither among the three Indian series nor between the Chamita and Bernalillo Spanish-Americans. There is, however, a distinction between the Indians and Spanish-Americans, the latter presenting more pronounced transversality of the palmar configuration as indicated by the significantly higher main-line index. This difference is

TABLE 4

Main-line indices: means

GROUP, AND NUMBER OF SUBJECTS	BOTH HANDS	RIGHT HANDS	LEFT HANDS	EXCESS IN RIGHT HANDS
Navajo (93).....	6.64 ± 0.10	7.62 ± 0.14	5.56 ± 0.12	2.06 ± 0.18
Hopi (59).....	6.97 ± 0.17	8.36 ± 0.19	5.58 ± 0.21	2.78 ± 0.28
Pueblo (131).....	6.99 ± 0.09	7.91 ± 0.12	6.07 ± 0.12	1.84 ± 0.17
Spanish-American, Chamita (110)....	7.63 ± 0.10	8.47 ± 0.13	6.79 ± 0.14	1.68 ± 0.19
Spanish-American, Bernalillo (97)....	7.72 ± 0.11	8.48 ± 0.15	6.95 ± 0.16	1.53 ± 0.22

in keeping with previously reported collections of Indians and European stocks. The degree of bimanual inequality also probably differs in the Indians and Spanish-Americans, being more marked in the Indians. Even in the lack of statistical significance, it is of interest that the Chamita Spanish-Americans are closer to the Indians than to the Bernalillo group both in respect to the mean index and degree of bimanual inequality.

There remains to be mentioned one other main-line feature, the occurrence of degenerate conditions of line C (formulated X and x) as well as total absence of the line (formulated O). Combining all three states of reduction of line C, it is apparent that no one of the five groups presents any noteworthy peculiarity. The usual marked excess of these conditions in left hands is present, and there are no significant distinctions among the five groups. Even if the figures are not significant, it should be mentioned that the Chamita series is closer to the Indians than to the Bernalillo with respect to the incidence of these reduced states of line C, the percentile frequencies for both hands being as follows: Navajo, 19.4; Pueblo, 17.6; Hopi, 17.8; Chamita, 17.7; Bernalillo, 22.7.

Plantar configurations.—Analysis of the plantar configurations is limited to the four areas in the distal region of the sole, the hallucal and three interdigital patterns. These are formulated by the method of Wilder ('18), and the results are available in tabulated detail, though

TABLE 5

Percentile frequencies of the plantar configurations

		SPANISH-AMERICANS[1]	NORTH-AMERICAN INDIANS[2]
HALLUCAL	A	51.0	71.2
	B	13.3	3.4
	C	...	1.0
	O	8.2	8.7
	W	27.5	15.8
FIRST INTERDIGITAL	O	69.4	76.5
	U	4.1	6.4
	Ω	23.0	13.2
	W	3.4	3.8
SECOND INTERDIGITAL	O	29.8	39.9
	U	54.4	55.7
	Ω	5.6	1.6
	W	10.2	2.7
THIRD INTERDIGITAL	O	91.5	88.3
	U	8.5	11.2
	Ω	...	0.5

[1] Weighted average: 206 subjects, the Chamita and Bernalillo series of this study.

[2] Weighted average: 311 subjects including the Navajo, Pueblo and Hopi of this study and 27 Shoshoni and Arapaho from an unpublished manuscript.

here the data (Table 5) are pooled in the two major groups. Differences of statistical significance among the Indian groups, as well as between the Chamita and Bernalillo series, are lacking. Yet the figures suggest that the Hopi are the least different from the Spanish-Americans. Since the Hopi occupy the same status in finger-print traits, the fact that palmar pattern frequencies do not fit into this generalization may be discounted on the basis of the small number of subjects. The main distinction of the Indians and Spanish-Americans is that in the former there is a tendency toward reduction of what might be termed pattern

intensity in all areas except the third interdigital. This tendency is variously reflected, according to the area concerned, by increase in frequency of patternless configurations and by reduction in number of pattern types B, Π and W.

DISCUSSION

Apart from serving as a record of dermatoglyphic features in North American Indians and in Spanish-Americans, the present analysis provides demonstration of: conformity to the "rule of all pairs" (see above) in the finger prints of North American Indians, hitherto not reported except for blacks and their hybrids; probable indications, in one group of Spanish-Americans, of dermatoglyphic signs of racial hybridization.

There is little that need be presented at this point by way of summary of the detailed data (see tables) relating to racial characteristics of finger prints, palms and soles. It will suffice to state that the distinctions between the Indians and the Bernalillo group of Spanish-Americans are in line with the differences previously observed between other Indian samples and European stocks. With the Bernalillo Spanish-Americans as a standard of comparison, the principal differences to be noted in the Indians are: (1) finger-print patterns are more frequently of the whorl type; (2) arches and whorls are distributed according to the rule of all pairs rather than the pair-group rule; (3) the dactylodiagram is of the "mongoloid" type; (4) the palmar hypothenar, second interdigital and third interdigital patterns are less frequent, while thenar/first interdigital and fourth interdigital patterns are more abundant; (5) the inclination of the general palmar configuration is less transverse, and there is possibly a more marked bimanual inequality with respect to this characteristic; (6) the configuration areas of the distal sole present configurations which tend to be of the less complex forms.

With regard to the signs of racial hybridization in the Chamita series of Spanish-Americans, the occurrence of finger-print traits paralleling the three items listed above as distinctions of the Indians is particularly striking. In addition, the statistically insignificant but suggestive deviation toward the Indian characteristics in several palmar features appears to be in support of the conclusion that the Chamita group contains an appreciable amount of Indian admixture. That it may date to the period of early Spanish domination in the Chamita area is an inter-

esting possibility, but from the nature of the case it is a possibility which eludes demonstration as fact.

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ON THE MORTALITY IN BROTHER-SISTER AND HUSBAND-WIFE PAIRINGS

BY ANTONIO CIOCCO[1]

INTRODUCTION

IN a systematic study of mortality in terms of familial aggregates the several kinds of simple family group-relations to be considered are those of (a) spouses, (b) sibs, (c) offspring. In an earlier paper of this series (Ciocco, 1940c) the results of an analysis of the age at death and cause of death of 2,571 married couples were discussed. In this paper the results of a similar analysis involving sibs as well as spouses will be presented.

The examination of the mortality in marital couples, since it deals with pairs of individuals who in general are not kin but who for a period of years from adulthood live in great intimacy sharing the same immediate environment, not only can lead to a better understanding of the effects on the incidence of certain major causes of death of the elements included in the immediate environment but also provides information for the evaluation of what association may be observed between sibs relative to cause of death. In contrast to spouses, sibs have a similar genetic background and generally share the same immediate environment from childhood to adult age and the same socio-economic status thereafter. Thus by comparing the frequency with which spouses and sibs, respectively, die from the same cause it is theoretically possible to arrive at a measure of the relative importance of the common genetic constitution and childhood environment on the one hand, and of the common adult environment on the other, relative to the development of the diseases which cause death in adult life. The results of such a comparison are reported in this paper which concerns the frequency

[1] Division of Public Health Methods, National Institute of Health, U. S. Public Health Service. This is the fifth of a series of papers entitled: Studies on the biological factors in public health. For the earlier papers cf. Ciocco, 1940 a, b, c; 1941.

with which the sibs and spouses, respectively, of persons who died from a certain cause have also died from the same cause.

MATERIAL

As has been repeatedly stated, in the investigation in progress it is particularly desired to develop methods of utilizing for this type of problem the material which is or could be available to all students of public health. In this and the other analysis the basic material consists of the official death records covering the period from 1898 to 1938 and contained in the files of the Washington County, Maryland, Health Department. Through the courtesy of Dr. W. R. Cameron, the former County Medical Officer, transcripts of these records have been made with the assistance of a W. P. A. project.[2]

For the purposes of the present analysis the starting point in the selection of the material has been the death records obtained on husbands and wives. From the time of the preparation of the report already cited the death records of 99 more married couples have been verified in the manner described, so that in total the records of 2,670 couples are used as the basis for the search of data on brothers and sisters. This search has been conducted as follows:

1. For each of the 2,670 husbands the record of a sister has been sought among all the death certificates of women above 18 years of age. (A special register has also been prepared containing the names of married, widowed, and divorced women but listed according to name of father and mother).

2. For each of the 2,670 wives the record of a brother has been sought among all the death records of men above 18 years of age. The names of the parents of the deceased women have been used as the means of identifying their brothers.

By this procedure the death records of one or more sisters of 561 husbands have been found and the death records of one or more brothers of 407 wives. In the case of 112 husbands and 108 wives the death records of more than one sib has been discovered. In order to compare pairs of sibs with married couples it has been necessary to select one sib only. This selection has been made by choosing the sib whose age at

[2] The author wishes to express his appreciation of the work of Miss B. Cheney in charge of the project and of Mr. C. R. Hathaway who supervised the transcription.

death was nearest to that of the spouse of the index case. In summary then, the material for this study consists of the death records of: (a) 968 persons or index cases, including 561 men and 407 women; (b) their spouses; and (c) an equal number of sibs who died at 18 years of age or over and of the same sex as the spouse.

It would be difficult to attempt to ascertain what, if any, bias has been introduced relative to cause of death by the method of selection used. The main condition bearing on the selection is that husbands, wives, and sibs all have died between 1898 and 1938 in Washington County and that their death certificates have been filed in the County Health Department. It cannot be said positively that this condition does not influence the randomness of the sample so far as concerns cause of death; however, as will be seen below, the frequency of the several causes of death in each of the groups examined does not seem to deviate much from the frequency expected in a comparable adult white population. It may be added that among the sibs of the index cases 128 died unmarried. These have been retained in the sample discussed after it was definitely seen that the final results were not altered by excluding them.

The mean age at death for all the husbands of the sample is equal to 70.2 ± .26 years; for all the wives, 67.3 ± .30 years; for the sisters of the index cases, 69.0 ± .39 years; and for the brothers, 67.4 ± .42 years. In passing it is well to note that the husbands have had a slightly longer duration of life than the wives. This was commented on in the earlier paper and until further data on the point are at hand the significance cannot be discussed adequately.

The cause of death as recorded on the death certificate has been coded according to the *International List* (1929 revision); and when two or more causes were mentioned the rules given in the third edition of the *Manual of Joint Causes of Death* (1933) have been followed. The proportional frequency of the major causes of death among the groups of men and women of this sample is presented in Table 1.

Although strictly comparable data regarding the general population are not available, the percentages shown in Table 1 agree well with what would be expected for the mortality of adults. Tuberculosis and arteriosclerosis are the least frequent causes while heart diseases is the most common. Among the four groups compared one notes differences other than those related to sex. For example, cancer and nephritis are more frequent in the brothers of the wives than in the husbands,

TABLE 1

Frequency of major groups of stated causes of death in samples of men and women. White persons who died in Washington County, Maryland, in the period 1898-1938

CAUSE OF DEATH	INTERNATIONAL LIST NUMBER	HUSBANDS		BROTHERS OF WIVES		WIVES		SISTERS OF HUSBANDS	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent
Tuberculosis (all forms)	23-32	51	5.27	20	4.91	71	7.33	34	6.06
Arteriosclerosis	97	62	6.40	23	5.65	40	4.13	15	2.67
Influenza and pneumonia (all forms)	11; 107-109	59	6.10	26	6.39	83	8.57	43	7.66
Cancer and other malignant tumors	45-53	64	6.61	35	8.60	112	11.57	73	13.01
Nephritis	130-132	122	12.60	65	15.97	92	9.50	71	12.66
Cerebral hemorrhage and softening	82	159	16.43	55	13.51	125	12.91	90	16.04
Heart diseases	90-95	231	23.86	96	23.59	249	25.72	132	23.53
Other and undefined or unknown causes	.....	220	22.73	87	21.38	196	20.25	103	18.36
All causes	.....	968	100.00	407	100.00	968	99.98	561	99.99

and in the sisters of the husbands than in the wives. The reverse is true with reference to tuberculosis and artiosclerosis. While the diffences noted are not large and could be due to chance, still they are to be kept in mind when considering the results presented below.

THE MORTALITY IN SIBS AND SPOUSES

The term index case is here used to indicate the husband or wife for whom the death record of an adult sib of the opposite sex has been uncovered. Having segregated the index cases according to cause of death, it is desired to determine (a) the frequency with which spouses and sibs have died also from the same cause, and (b) whether this frequency is greater than that observed in the total sample from which the spouses and sibs, respectively, are drawn. The data presented in Table 2 furnish an answer to the problem as postulated.

TABLE 2

Percentages of sibs and of spouses who died from the same cause of death as the index cases

CAUSE OF DEATH OF INDEX CASES	NUMBER OF INDEX CASES	PERCENTAGE DEAD FROM STATED CAUSES AMONG			
		Sibs of index cases	Spouses of index cases	All sibs in sample	All spouses in sample
Tuberculosis	58	13.79	17.24	5.58± .74	6.61± .80
Arteriosclerosis	51	0	7.84	3.93± .62	5.27± .72
Influenza and pneumonia	67	11.94	16.42	7.13± .83	7.75± .86
Cancer	82	12.20	17.07	11.16±1.01	9.71± .95
Nephritis	117	12.82	11.11	14.05±1.12	10.02± .97
Cerebral hemorrhage	149	14.09	17.45	14.98±1.15	13.95±1.11
Heart diseases	239	23.01	31.38	23.55±1.36	24.90±1.39

Considering first of all the spouses of the index cases it is seen that among them the proportion of those who have died from the same cause as the index case is in all cases higher than the proportion of all spouses who died from the specific causes mentioned. However, only with respect to tuberculosis, influenza and pneumonia, cancer, and heart diseases do the differences between the spouses and the sample from

which they are drawn probably exceed the expectations of chance. This finding is not surprising in view of the results reported in the previous paper and indicates that this sample of 968 couples is representative of the total from which it has been selected.

When the frequency with which the sibs of the index cases died from the same cause as did the index cases is compared to the frequency with which all sibs died from that cause it is seen that only in the case of tuberculosis is the difference statistically significant.

Summarizing the main findings shown in Table 2, it appears that:

1. Among the index cases that died of tuberculosis 17.2 per cent of their spouses and 13.8 per cent of their sibs also died from tuberculosis. Thus more spouses and sibs of persons who died from tuberculosis died from this disease than would be expected on the basis of chance alone.

2. With reference to the index cases that died from either influenza and pneumonia, cancer, or heart diseases, more of their spouses died from the same cause than the spouses of other persons. The sibs of these index cases died from the same cause with about the same frequency as the sibs of persons who died from other causes.

3. The sibs and spouses of persons who died from either arteriosclerosis, nephritis, or cerebral hemorrhage died from the same cause with a frequency not significantly different from that of the sibs and spouses of persons who died from other causes.

Therefore, one is led to infer that only with reference to tuberculosis is there concurrence in the cause of death of siblings, and for tuberculosis one notes that more spouses than sibs of the index cases died from the same cause. The difference between the percentage of spouses and of sibs who died from the same stated cause as the index case is not statistically significant with regard to this or any cause, which of course must be expected, due to the smallness of the sample involved.

The above finding may also be demonstrated by segregating the sexes and comparing brothers and sisters and husbands and wives. The data on this point are presented in Table 3.

It is seen from Table 3 that:

1. The relative frequency of tuberculosis as a cause of death among the wives of men who died of tuberculosis is practically three times as

TABLE 3

Percentages of (a) sisters and (b) wives who died from the same cause of death as their respective brothers and husbands, and percentages of (c) brothers and (d) husbands who died from the same cause of death as their respective sisters and wives

CAUSE OF DEATH OF THE MEN OR THE WOMEN	PERCENTAGE DEAD FROM STATED CAUSE AMONG THE					
	Sisters of the men	Wives of the men	All women in sample	Brothers of the women	Husbands of the women	All men in sample
Tuberculosis	16.00	19.61	6.87±.57	12.90	14.08	5.22±.51
Arteriosclerosis	0	6.45	3.56±.42	0	10.00	6.30±.55
Influenza and pneumonia	13.33	18.64	8.21±.62	10.53	13.25	6.15±.55
Cancer	14.29	21.88	11.98±.74	8.50	12.50	6.92±.58
Nephritis	10.95	10.66	10.74±.70	12.93	14.13	13.38±.77
Cerebral hemorrhage	14.79	16.35	14.31±.80	13.82	20.80	15.55±.82
Heart diseases	23.21	32.47	24.74±.98	23.91	30.12	24.17±.97

high as that for all women. The relative frequency among sisters is 2.3 times that for all women. In both instances the deviations are statistically significant.

2. Influenza and pneumonia occurred as a cause of death among wives of men who died from these causes 2.3 times as often as among all women. These causes of death also occurred more often among the sisters of such men but the superiority is not statistically significant.

3. Cancer was a cause of death of wives of the men who died of cancer almost twice as much as of all women; and heart diseases occurred 1.2 times more among the wives of men who died from heart diseases than among all women. The greater frequency in both cases is probably outside the limits of chance deviation.

4. For none of the specific causes, except tuberculosis as mentioned, do sisters of men who have died from the stated conditions demonstrate a significant tendency to die also from the same cause.

With reference to the cause of death of husbands and of brothers of the women who died from the specific causes mentioned the same rela-

tions hold as those noted in the items 1 to 4. From all these findings it seems safe to conclude that relative to the mortality from tuberculosis there is association between brothers and sisters as well as between husbands and wives. Relative to the mortality from influenza and pneumonia, cancer, and heart diseases this sub-sample of husbands and wives reveals the same as that brought out in the earlier paper.

MORTALITY IN SIBS AND SPOUSES RELATIVE TO DEATHS INVOLVING THE RESPIRATORY AND CARDIOVASCULAR-RENAL SYSTEMS

In the study of mortality, when investigating relationships that could involve the biological constitution, it is pertinent to consider the causes of death not only singly—that is in terms of the clinical or etiological patterns on which they are more or less based—but also in broad groups which refer to major organ-systems. This was pointed out by Pearl (1920) some time ago; and while in the present stage of this study it is not desired to classify the causes according to a system such as that devised by Pearl, it is possible to group some of the major causes of death and thus discuss in addition to the above the mortality from causes connected primarily with the fatal breakdown of (a) the respiratory system, and (b) the cardiovascular-renal system. In the first are combined the deaths from influenza and pneumonia, and tuberculosis of the respiratory system. (It so happens that every case of death from tuberculosis in this sub-sample is from pulmonary tuberculosis). This group will not contain all the deaths from respiratory diseases because deaths from bronchitis, diseases of the larynx, etc. will not be included but their omission can have very little influence on the final results since they are numerically unimportant. The second major group will include the deaths from heart diseases, nephritis, arteriosclerosis, and cerebral hemorrhage. The frequency with which sibs and spouses of persons who died from either of these two groups of causes also died from the same group of causes is presented in Table 4.

The data presented in Table 4 reveal some interesting and suggestive points. In the first place among both the sibs and the spouses of persons who died from respiratory diseases the proportion that died from the same causes is higher than that observed among the sibs and and the spouses of persons who died from other causes. In both cases the differences are statistically significant. This finding with respect to the spouses is, of course, to be expected since, as was shown above,

TABLE 4

Percentages of sibs and of spouses who died from the same causes of death as the index cases who died from (a) respiratory diseases, (b) cardiovascular-renal diseases

CAUSE OF DEATH OF INDEX CASE	NUMBER OF INDEX CASES	PERCENT DEAD FROM SAME CAUSES AMONG	
		Sibs	Spouses
Respiratory diseases.....	125	21.6±3.7	28.0±4.0
Other than respiratory diseases.....	843	11.2±1.1	12.3±1.1
Cardiovascular-renal diseases.....	555	60.3±1.8	55.6±2.1
Other than cardiovascular-renal diseases	412	51.5±2.5	52.2±2.5

spouses of persons who died from tuberculosis and from influenza and pneumonia demonstrate a significant tendency to die from these causes. It was also seen that sibs of persons who died from tuberculosis died from this disease in significantly greater relative number than the sibs of other persons; but among the sibs of the dead from influenza and pneumonia, while the proportion of deaths from these diseases was larger than among other sibs, the magnitude of the difference could be due to chance. By combining tuberculosis and influenza and pneumonia it results that for the respiratory group of causes relatively more sibs and more spouses of persons who have died from such causes die from the same group of causes than sibs and spouses of persons who died from other causes. This tendency is slightly but insignificantly more marked in spouses.

By grouping the deaths from heart diseases, arteriosclerosis, cerebral hemorrhage, and nephritis the results so far obtained and illustrated in Tables 2 and 3 are altered. From Table 4 it appears that the relative number of spouses who died from cardiovascular-renal diseases is not significantly greater among the spouses of persons who died from such diseases than among the spouses of persons who died from other causes. This is noted even though for heart diseases alone there is a tendency for husbands and wives to die from the same cause. Instead, among the dead sibs of persons who died from cardiovascular-renal diseases, these causes of death have occurred with relatively greater frequency

than among the dead sibs of persons who died from other causes. This superiority is statistically significant and seems to indicate that, while sibs of persons who died from either arteriosclerosis, heart diseases, cerebral hemorrhage, or nephritis do not tend to die from the same cause, they apparently are more apt to die from one of these causes than the sibs of persons who died from other causes. On the other hand the association relative to cause of death in husbands and wives is apparently delimited to heart diseases alone and does not include other causes contained in the cardiovascular-renal group.

DISCUSSION

The principal results of this study are:

1. In this sub-sample of husbands and wives the association relative to death from (a) tuberculosis, (b) influenza and pneumonia, (c) cancer, and (d) heart diseases, noted in the original sample and reported upon is also present.

2. Among the dead brothers and sisters of persons who have died from tuberculosis, this is also a cause of death almost as frequently as among the spouses of such persons and more frequently than among the sibs of persons who died from other causes. The same finding is noted when deaths from tuberculosis and from influenza and pneumonia are grouped together in what may be called deaths due to respiratory diseases.

3. Death from the same cause has not occurred more often than expected among the sibs of persons who died from cancer, arteriosclerosis, nephritis, cerebral hemorrhage, and heart diseases. However when the last four causes are combined to form the cardiovascular-renal group of causes, among the sibs of persons who died from these causes the proportion that died from the same group of diseases is higher than that of the sibs of persons who died from other causes. It may be added that no such relationship is observed for spouses.

That in brother-sister pairs and in marital couples almost the same degree of association relative to the mortality from tuberculosis is noted would indicate that the genetic constitution plus the common immediate childhood environment affects the incidence of this disease almost the same as the close contact and immediate environment of married persons. There is no question that tuberculosis is a familial disease. The only point of argument concerning this aspect is the

relative importance of the genetic constitution. The findings in this paper could be explained on the basis of infection alone and a common source of infection in childhood or contagion at the time could have as a consequence the findings observed here. If this assumption is accepted then the time lag between the period of infection in the sibs, presumably in childhood, and the age at death in adult and old age is noteworthy. On the other hand observations can be introduced, those of Diehl and v. Verschuer (1933) on twins for example, revealing that in the manifestations of tuberculosis some rôle must be attributed to the genetic constitution. If this is so, the comparison between pairs of sibs and marital couples would suggest that it is probably not of the same magnitude as the factor of contagion produced by the intimate contact between husbands and wives and between brothers and sisters living together in childhood (or between the children and parents).

Bearing on the view that the constitutional element in the mortality from tuberculosis, whatever its value, is not nil are the findings relative to the mortality from influenza and pneumonia. The proportion that died from these causes among the sibs of persons who also died from them is higher than that among sibs of persons who died from other causes. True, the difference could be due to chance; but when influenza and pneumonia and tuberculosis are grouped together then there is apparent a statistically significant superiority in the relative number of dead from these causes among the sibs of persons who died from respiratory diseases over the sibs of persons who died from other causes. Since influenza and pneumonia are acute infectious diseases and the death of the sibs from these causes was not simultaneous, the association between sibs living apart could not be well explained without postulating a high carrier rate. Therefore, assuming no statistical artifact, the above findings might suggest that the influence of a constitutional factor manifests itself with reference to the kind of respiratory system rather than to the kind of reaction to a parasite such as the tubercle bacillus or the pneumococcus. This view found favor with some early students of modern somatologic constitution and could explain the observations on physique and tuberculosis and pneumonia (cf. Reed and Love, 1933; Dublin and Marks, 1938).

With regard to cancer the data of this study cannot be employed to support the view that the biologic constitution is of importance in its etiology. It has been generally remarked that the negative results

repeatedly obtained in the study of cancer pedigrees is related to the age element in the incidence of the disease. While it may be, the method of this approach has obviated to some extent this difficulty but the results are negative also. As a consequence, the association observed between husbands and wives in the mortality from this cause, if true, probably cannot be explained except as the result of the common environment or the interaction between spouses.

The findings relative to heart diseases and to the so-called cardiovascular-renal diseases offer also the possibility to clarify the action of the constitutional factor in disease. For the mortality from heart diseases alone it is suggested that some association is present between husbands and wives. But none can be advanced for the deaths from arteriosclerosis, nephritis, and cerebral hemorrhage nor for deaths from these causes combined and added to heart diseases. The inference would then be that the association between husbands and wives is a consequence of one specific entity included in the heart diseases complex. Assuming that the association is real it obviously must be due to one of the clinical entities that can be affected by elements in the immediate common environment of spouses. The findings relative to sibs are entirely different, as has been pointed out. Some association between brothers and sisters is apparently demonstrated only when the cardiovascular-renal deaths are considered together. Under this condition it means that there is concurrence in sibling pairs relative to death from one or the other of the clinical entities included in the group. It is well to remark that similar findings were obtained by Pearl (1936) who was led to conclude from his study "that the innate biological constitution may play a significant, and possibly important, rôle as a factor in the etiology of cardiovascular-renal disease, . . .". It would follow from this that the constitutional factor exerts its action generally in terms of weakness or strength of the circulatory system rather than specifically in relation to the single clinical entities.

From the findings of this analysis and the inferences to be drawn from them one is first of all struck by the obvious wealth of needed information on public health problems, and particularly those of the chronic diseases that could be presumably uncovered by the study of the familial group. In addition, it seems rather evident that in the attempt to seek a measure of the constitutional factor in the incidence of disease, it cannot be expected that the biological element can be

clearly discerned in relation to clinical patterns, but probably emerges more definitely in relation to adequacy or inadequacy of organ systems. The inferences which the comparison of mortality in sibs and spouses suggest may be summarized as follows:

1. The common immediate environment, or conditions depending upon the intimate personal contact, or both, seem to be especially important in the occurrence of mortality from tuberculosis, influenza, pneumonia, cancer, and heart diseases.

2. While the biologic constitution seems also to influence to some degree the occurrence of the mortality from tuberculosis, its apparent influence may be primarily a manifestation of the rôle it plays in the fatal breakdown of the respiratory system. Besides the respiratory system, on the basis of these data, it can be presumed that the biologic constitution is an important factor in the mortality from causes related to the cardiovascular-renal system.

SUMMARY

The frequency with which the same cause of death is observed in pairs of sibs of the opposite sex and in married couples has been compared with respect to tuberculosis, arteriosclerosis, influenza and pneumonia, cancer, nephritis, cerebral hemorrhage, and heart diseases. The comparison has been made between 968 pairs of brothers and sisters and an equal number of husbands and wives. One sib of each pair is also a spouse.

The 2,904 persons of this sample are all white adults who died between 1898 and 1938 in Washington County, Maryland.

The analysis of the data reveals:

1. As previously reported, some association between husbands and wives relative to cause of death is observed for tuberculosis, influenza and pneumonia, cancer, and heart diseases.

2. Among the sibs of persons who died from tuberculosis, 14 per cent died from the same cause. This percentage is 2.5 times as high as the relative frequency of tuberculosis in all the sibs of the sample. Among the spouses of the persons who died from tuberculosis, 17 per cent died from this cause, while among all spouses the percentage does not equal 7.

3. When the deaths from tuberculosis and from influenza and pneumonia are combined, it is found that 22 per cent of the sibs and

28 per cent of the spouses of persons who died from these causes also died from the same causes. The relative frequency of death from these causes is respectively 11 and 12 per cent among the sibs and spouses of persons who died from other causes.

4. When the deaths from heart diseases, cerebral hemorrhage, arteriosclerosis, and nephritis are grouped together it is observed that 60 per cent of the sibs of persons who died from these causes also died from the same causes. This group of diseases constituted the cause of death of only 51 per cent of the sibs of persons who died from causes not included in the group.

5. The relative frequency of sibs who died from the same cause is not significantly different from the expected with respect to cancer, nor in the case of influenza and pneumonia, arteriosclerosis, cerebral hemorrhage, nephritis, and heart diseases when these causes are considered singly.

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THE PHYLOGENY OF THE HUMAN FOREARM EXTENSORS (*Concluded*)

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ANTEBRACHIO-MANUAL MUSCULATURE

Ulno-carpal extensor series

THIS component is represented in urodele amphibians by a *supinator manus* and an *extensor digitorum brevis*. The former, situated deep to the humero-dorsalis, arises either from distal end of ulna and proximal ulnar carpus (*Cryptobranchus, Megalobatrachus*) or from carpus alone (*Necturus, Triton, Salamandra*). It runs somewhat obliquely to insert upon the radial base of the 1st metacarpal bone. In *Rana catesbiana* (Haines), the large and specialized supinator manus arises by two heads, ulnar and humeral; the latter head probably is a brachio-antebrachial derivative that has joined the true supinator manus.

The *extensor digitorum brevis* of urodeles is in the same plane with the supinator manus and sometimes is connected with the latter muscle. Typically (as in *Salamandra*) it consists of several asymmetrically disposed small muscles arising from the ulnar part of the proximal row of carpal bones and inserting dorsally by slender tendons upon the phalanges of the individual digits. At times, origin also is from the ulna (as in *Megalobatrachus*). The tendons in some forms (*Cryptobranchus, Megalobatrachus*) are united with those of the extensor carpi intermedius.

In *Necturus,* the so-called short extensors (Brooks, Ribbing, Wilder, Howell) are 4 symmetrically arranged muscles arising from the distal row of carpal bones, but not at all from the proximal (Fig. 1). It is extremely probable, however, that Haines (1939) is correct in regarding them as dorsometacarpales (manual series) rather than extensores breves (antebrachio-manual series). In the absence of either of these two groups, there may be no criterion by which the remaining units can

be unequivocally identified, for migration of origin (as from carpus to metacarpus or vice versa) easily is accomplished. But since the muscles of *Necturus* in question arise from the distal carpalia and are symmetrically arranged, it is most logical to regard them as true dorsometacarpals—for in these features they resemble the undoubted members of that group as encountered in other urodeles. The extensor digitorum brevis therefore seems completely to have disappeared, leaving the supinator manus as the sole representative of the ulno-carpal musculature. If this interpretation is valid, then *Necturus* is unique among the known urodeles.

In reptiles, the homologue of the supinator manus often is termed *abductor pollicis longus,* although it still functions as a supinator. It now usually arises only from the ulna (*Sphenodon, Iguana,* Chelonia) but the primitive carpal origin likewise can persist (*Varanus*) (Figs. 2, 18). In *Crocodilia* (and the turtle *Cyclanorbis*), there is origin from both bones of the forearm, as in some mammals. Insertion is upon the radial base of metacarpale I, but in *Crocodilia* entirely upon the carpus (radiale).

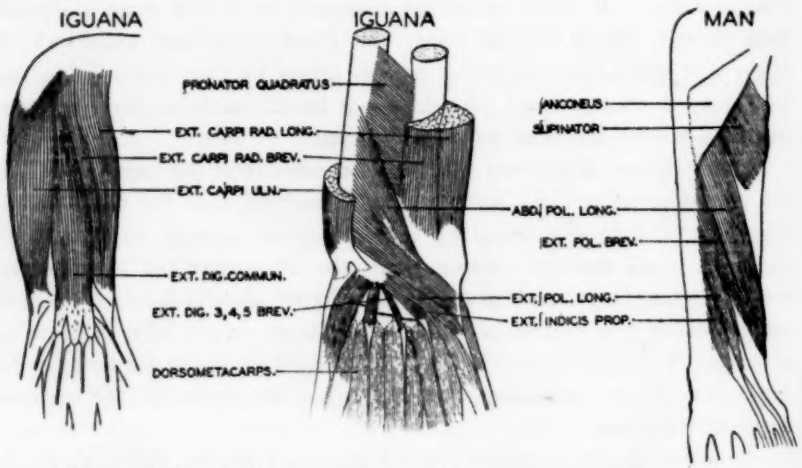


FIG. 18. DORSAL MUSCULATURE OF ANTEBRACHIUM AND MANUS

Superficial (left) and deeper (middle) views of *Iguana,* and (right) deeper muscles of Man. (After Howell, 1936b.) EXT. DIG. COMMUN., extensor carpi intermedius; EXT. CARPI RAD. LONG. AND BREV., extensores radiales longus et brevis. The anconaeus of man belongs with the triceps brachii; while the supinator, according to the view advocated in the present paper, is not a deep extensor component.

The primitively asymmetrical *extensor digitorum brevis* of reptiles arises only from the proximal ulnar carpus in some animals (*Sphenodon, Iguana*), from both carpus and lower ulna in others (*Sphenodon, Varanus, Alligator,* Chelonia), and inserts upon the phalanges of the five digits (Figs. 2, 18).

Brooks (1889) was the first to point out that the deep extensors of the mammalian forearm actually are nothing more than the short or ulno-carpal extensors of lower tetrapods that have migrated upward from the wrist along the ulnar side of the antebrachium deep to the humeral muscles. This thesis later was vigorously developed by both Ribbing (1907) and Howell (1936b). The contrary claim of Sutton (1888)—that the deep forearm extensors arose primitively from the radial epicondyle of the humerus and the olecranon and then gradually migrated down the ulna—and the similar conclusion of Bühler (1902), both are based chiefly upon the doubtful evidence of human anomalies and are entirely contradicted by comparative anatomical data.

The supinator manus (abductor pollicis longus) of amphibians and reptiles is represented in mammals by the *abductor pollicis longus* and the extensor digitorum brevis by the *extensor digitorum profundus* (including extensor pollicis longus, extensor indicis proprius, extensor medii proprius, and the occasional deep extensors of the other digits) (Figs. 3-14, 16, 17). The *extensor pollicis brevis* clearly is a derivative of the long pollical abductor.

An *abductor pollicis longus* regularly is present in mammals. It usually arises from the dorsal and radial aspects of the ulna, while in many forms, in correlation with its strong development, the fibres also have spread radialward so as to gain additional origin from radius and interosseous membrane. In *Ornithorhynchus* (Howell) the tendon receives a carpal slip that possibly represents a primitive more distal origin. An origin from the radial epicondyle of the humerus (as in *Rana*) has been reported for *Manis* (Leche), *Cyclopes* (Humphry), and *Tarsius* (Burmeister); this represents either an extreme specialization in upward migration of the muscle, or has resulted from fusion with superficial extensor elements.

The insertion of the long abductor frequently involves only the radial base of metacarpale I or the most radial metacarpal when the first is lost (monotremes, many marsupials, insectivores, manatee, some examples of *Bradypus,* ungulates and primates); in other forms both the metacarpal and the adjacent radial sesamoid bone that frequently is

termed "pre-pollex" (*Didelphis,* rodents, many primates), or even the sesamoid alone (some rodents); in many animals both the metacarpus and the adjacent carpus (many marsupials and primates, pangolin, tapir, hyrax); and in some even the carpus alone (occasionally in marsupials, some Bradypodidae and Myrmecophagidae, bats). An *extensor pollicis brevis* is found only in certain primates.

In Tupaioidea and primates the abductor pollicis longus normally arises from both of the antebrachial bones (including the interosseous membrane). Origin occasionally is restricted to either ulna (Fig. 11) or radius (Fig. 5). Burmeister claimed, incorrectly, that origin in *Tarsius* was confined to the radial epicondyle beneath m. supinator. The muscle uniformly is very powerful and still plays an important part in supination of the hand except where an ulnar head is absent. It is robust even in *Ateles* and *Colobus,* despite their vestigial thumb.

Not infrequently the muscle belly or its tendon, especially the latter, is split longitudinally, so that insertion often is by more than one terminal tendon. Two distinct tendons attaching to the same bone, especially the metacarpal, occur not uncommonly, particularly in man and the three great apes. Bony insertion in primates (including Tupaioidea) can be in 5 distinct ways: (1) On carpus alone; (2) On radial base of metacarpale I, radial carpal sesamoid, and carpus proper (customarily greater multangular) (Fig. 5); (3) On metacarpale I and carpus proper (usually gr. multangular) (Fig. 8); (4) On metacarpale I and sesamoid (Fig. 10); and (5) On metacarpale I alone (Fig. 6). Of these types, 2 and 3 probably are the more primitive and type 5 the most advanced, but the reverse may be true in the light of conditions in amphibians and reptiles.

Type 1 insertion has been described only for one specimen of *Callithrix jacchus* (Duckworth, 1904). The type 2 insertion is normal for some monkeys of the Old World sub-family Colobinae (*Pygathrix, Nasalis*). It also has been found in *Tupaia, Lemur,* gibbon (38 p. c., or 5/13), chimpanzee (18 p. c., or 5/28), and orang-utan (8 p. c., or 1½/18). Apparently it never occurs in platyrrhines, gorilla, nor man, in which a radial sesamoid normally is lacking. In my specimens of *Tupaia* there actually was no direct insertion upon the metacarpal, but rather upon the capsule of the first carpo-metacarpal joint; yet action on the latter bone undoubtedly was secured.

An insertion of type 3 is the rule for the three great apes—chimpanzee (82 p. c.), gorilla (71 p. c., or 10/14), orang (64 p. c.)—and *Papio* and possibly for some groups of men. It also is found in many

platyrrhine monkeys (*Oedipomidas, Leontocebus, Cebus, Ateles*) and a number of gibbons (31 p. c.). The carpal attachment customarily is the stronger in the great apes. This type of insertion never has been reported for lemurs.

Type 4 insertion is normal for the Old World monkeys *Macaca* and *Colobus* and is common in lemurs (*Daubentonia, Galago, Perodicticus*). It also occurs as a variant in *Tarsius,* gibbon (23 p. c.), orang (11 p. c.), and gorilla (7 p. c.). This type seems never to have been found in platyrrhines, chimpanzee, nor man.

The type 5 insertion habitually is present in both *Ptilocercus* and *Tarsius* and also is found in some lemurs (*Lemur, Nycticebus, Perodicticus*), platyrrhines (*Callithrix, Cebus, Alouatta, Ateles*), and man (v. i.). It likewise has been reported for *Tupaia,* gorilla (21 p. c.), orang (17 p. c.) and gibbon (8 p. c.). This arrangement appears to occur in neither the catarrhine monkeys nor the chimpanzee.

Exclusive carpal attachment thus very rarely is found in primates, so that the tendon practically always reaches the metacarpus. Hence, any tendency to restrict the insertion in this group is manifested by concentration of the fibres distally, upon the metacarpal base. Anomalous, phylogenetically unimportant slips of insertion may exist—to lower radius or various parts of the hand (gibbon, orang, chimpanzee).

The normal insertion of the long abductor of man usually is considered to be limited to the radial base of metacarpale I. Additional slips blending with the origin of m. abductor pollicis brevis and attaching to the greater multangular are recognized, however, as being quite common. Parsons and Robinson (1899), in a collective study of 127 English arms, found that the human abductor pollicis longus can insert upon at least 6 different structures, involving, in the order of greatest frequency, metacarpale I (in all), m. abductor pollicis brevis (59 per cent), greater multangular (58 p. c.), m. opponens pollicis (16 p. c.), basal phalanx of thumb (7 p. c.), and proximal joint-capsule of metacarpale I (2 p. c.). The most frequent combinations of the 13 encountered were: (1) Met. I, gr. multangular, abd. poll. brevis (25 p. c.); (2) Met. I, abd. poll. brevis (21 p. c.); and (3) Met. I, gr. multangular (19 p. c.). Insertion limited to the metacarpal occurred in only 10 per cent, yet *osseous* connection was confined to that bone in 37 per cent. The occasional slip from the long abductor to the first phalanx of the thumb is to be regarded as a rudimentary, incompletely separated extensor pollicis brevis component (v. i.). In Chinese (Wagenseil),

two or more tendons of insertion is the rule (2 occurring in 69 p. c.). Hence it appears likely that a double insertion of some sort is normal for man. One of the tendons usually has carpal attachment, bony or otherwise, although the osseous connection occurs less frequently than in other catarrhine primates.

Use of the name "abductor pollicis longus" (or "extensor ossis metacarpi pollicis") sometimes has been restricted to that portion of the long abductor inserting upon the carpus, the division to the pollical metacarpal bone then being dubbed "extensor pollicis brevis" (or "extensor primi internodii pollicis"). This I regard as unfortunate. The metacarpal portion merely is a part of the abductor proper and there is no proof that it is strictly homologous to the *extensor pollicis brevis* of man. The use of the term "extensor pollicis brevis" correctly should be reserved for such part of this muscle complex as inserts upon the *phalangeal portion* of the thumb.

Exclusive of man, such a structure seems to have been found only in the gorilla (56 p. c., or 9/16) and the gibbon (7 p. c., or 1/15). Keith (1899), who also utilized the literature, wrote that the tendon of the long abductor sent a slip to the proximal pollical phalanx in one chimpanzee out of 20 reported upon. No such statement, however, has been encountered by me in any other publication.

The short pollical extensor indubitably is nothing more than a differentiated portion of the abductor pollicis longus whose tendon has migrated distally on to the basal phalanx of the thumb. When present in the gorilla it virtually always remains connected with the parent muscle. Thus in the animals dissected by Duckworth (1904), Eisler, Hepburn, Pira, and Sommer it merely was a derivative of the metacarpal division of the abductor. Symington described the short extensor as a small tendon prolonged from the abductor. In Duvernoy's animal the belly of the ext. brevis was separate but the muscle was somewhat fused below with the part of the abductor that went to metacarpale I. Chapman (1878) alone suggested complete separation of the short extensor, but his bare statement that it was "distinct" in his gorilla is obscure. The condition of my own specimen precludes any decision on this matter. In the single gibbon in which an extensor pollicis brevis has been found—the fetus studied by Deniker—it arose from the radius but was only partially separable from the long abductor. Insertion in the apes always is on the first phalanx of the thumb.

The independent extensor pollicis brevis of man arises from radius and interosseous membrane (rarely from ulna) distal to the abd. poll. longus and inserts dorsally upon the phalanges of the thumb (Fig. 14). It regularly is present, this in contrast with all other primates. Complete absence—or lack of differentiation—occasionally occurs, however (in 1-6 p. c.: Wagenseil, Wood, Parsons and Robinson). In other instances it can be more or less fused with the long abductor of the thumb as in gorillas (found by Parsons and Robinson in 37 p. c. of English, but by Wagenseil in only 6 p. c. of Chinese). Another type of incomplete differentiation from its parent muscle is represented by the occasional cases in which it is intimately associated with a metacarpal insertion.

Phalangeal insertion takes place in 3 different ways: (1) Entirely upon the first phalanx of the thumb; (2) Upon both phalanges; and (3) Entirely upon the last phalanx. In English (Parsons and Robinson, 118 arms), type 1 is normal (72 p. c.), type 2 not uncommon (21 p. c.), and type 3 rare (7 p. c.). Among Chinese (Wagenseil, 64 arms), types 1 (53 p. c.) and 2 (47 p. c.) are of nearly equal frequency, but type 3 seems never to occur. In Bantus (McGregor, 100 arms), types 2 and 3 are found in the vast majority of instances, type 1 being present in only 5 per cent. As noted above, it is quite clear that the extensor pollicis brevis has been produced phylogenetically by distal migration of a long abductor component. Apparently this process is not yet at an end in man. Insertion partially or (especially) entirely upon the terminal phalanx is a progressive character, exclusively on the basal phalanx a more primitive character—as evidenced also by the fact that the rudimentary short extensor of gorilla and gibbon, when present, reaches only the first phalanx. It therefore follows that in this particular feature Bantus are more advanced than either English or Chinese. The contrary view of McGregor (1926), that the primitive attachment of the short pollical extensor is upon the terminal phalanx and that the tendon is migrating to the base of the first, entirely ignores all comparative myological data.

Several years ago, in the dissecting room, I encountered the most extreme, progressive type of extensor pollicis brevis that I ever have seen, and one that seems never to have been recorded in the literature. In each arm of an adult female Negro, the customary abd. poll. longus and ext. poll. brevis were missing, being replaced topographically by a very large and powerful muscle that inserted partly upon the first

phalanx of the thumb and partly upon the second phalanx together with the ext. poll. longus. There was no attachment to either metacarpus or carpus. Obviously the entire abductor complex had developed into an extensor brevis.

The *extensor digitorum profundus,* comprising the more distal portion of the ulno-carpal extensor series, is represented in all mammals, excepting only cetaceans, hyrax, and at least many ungulates. Its form and extent, however, are quite variable. In monotremes its tendons are still fused with those of the extensor communis, but they are separate in other mammals. Origin commonly is from the ulna adjoining the long abductor, but in some forms also from radius and interosseous membrane.

Insertion is on the dorsal surfaces (frequently ulnar half) of the digits, deep to the tendons of the ext. communis. The muscle-belly and its tendons exhibit many types of division. Not uncommonly a single tendon bifurcates to supply two adjoining fingers, a condition that may be primitive for mammals, as postulated by Ribbing (1907); hence two tendons for a single finger sometimes occur. The insertion may primitively involve digits I-IV (some marsupials, many primates) or even all five digits (*Echidna*); more commonly, however, I-III (*Ornithorhynchus, Solenodon, Manis,* some marsupials, rodents and carnivores, many primates); or only I and II (most insectivores, bats, some marsupials, rodents and carnivores, a few primates). The most radial tendon (extensor pollicis longus) sometimes is absent, the muscle then supplying II-IV (*Orycteropus, Echidna, Ateles*), II and III (*Orycteropus, Ornithorhynchus, Colobus*), or merely II (*Chrysochloris*). A tendon for the 5th digit is of extremely rare occurrence and to my knowledge has been found only in *Echidna* and as a variation in some primates.

The extensor digitorum profundus of primates (and tupaioids) regularly takes origin from the ulna (often including the interosseous membrane), frequently for a considerable extent. Additional origin from the radius has been reported for specimens of *Tarsius,* orang-utan, chimpanzee, gorilla, and man; and from the radial epicondyle of the humerus for a *Nasalis larvatus* (Kohlbrügge, 1897) and a gibbon (Deniker). Origin from the radius alone has been claimed for an *Ateles paniscus* (Meckel, cited by Kohlbrügge, 1897).

In all groups of primates except Tarsioidea and platyrrhine monkeys the deep extensor mass normally is divided rather definitely into two

parts: (1) An *extensor pollicis longus,* inserting only upon the thumb, and (2) an *extensor proprius* of other digits, arising more distally. This form of cleavage customarily does not occur in *Tarsius* and the platyrrhines (apparently never in Callitrichidae, according to several authors). In these animals, instead of the usual long pollical extensor, there is an *"extensor pollicis et indicis longus"* attaching to both the pollex and the 2nd finger (Fig. 19f, g, h). Burmeister, however, has reported a separate ext. poll. longus for *Tarsius,* while both Gruber (cited by Sommer) and I found one in *Cebus.* The common long extensor of thumb and index finger also has been noted in one gorilla (Hepburn) and is not of excessive rarity in man (in 1-5 p. c.: Wagenseil, Wood, Gruber). It even can co-exist with both the normal ext. poll. longus and ext. ind. proprius in man (as in *Didelphis,* Fig. 19a), arising from the ulna between these two muscles. Such a muscle seems never to have been found in lemurs, Old World monkeys, gibbons, orangs, nor chimpanzees. In *Tupaia,* the tendons of the two parts of the profundus can be connected in the hand or the entire deep extensor mass can form a single primary tendon with three terminal divisions. The complete emancipation of the portion supplying the thumb to become a true extensor pollicis longus, which exists in most groups of primates, undoubtedly is correlated with the increased physiological independence of the pollex characteristic of this order. It is noteworthy that a common extensor of the two radial digits normally is found only in those primate forms—tarsiers and platyrrhines—in which such functional autonomy has been but slightly attained.

The extensor pollicis longus normally inserts only upon the terminal phalanx of the thumb. A double insertion, upon both phalanges, is frequent only in the anthropoid apes; but likewise is found in *Tupaia,* Old World monkeys, and man (in 3 p. c.: Parsons and Robinson).

Kohlbrügge (1897) concluded that the long extensor of the pollex is weaker in the three great apes than it is in man. This might be expected in view of their degenerate thumbs. It is not true, however, of all individuals. Furthermore, this relative weakness is not confined to the Pongidae, for the muscle can be but poorly developed in other Anthropoidea, such as *Hylobates, Macaca,* and *Cebus.* The spider monkey, *Ateles,* regularly lacks a long extensor for its vestigial pollex although Huxley suggested that it occurred in his specimen. This muscle likewise is absent in *Colobus,* which also possesses a dwarfed

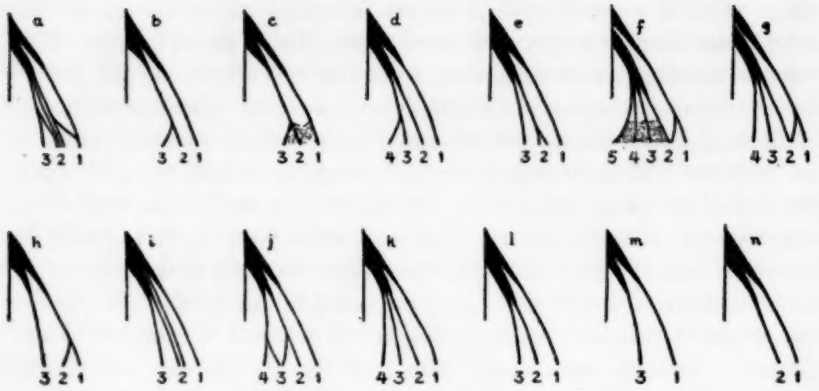


FIG. 19. DIAGRAMS OF THE EXTENSOR DIGITORUM PROFUNDUS IN DIDELPHIS (a), TUPAIA ♀ (b), TUPAIA ♂ (c), LEMUR (d), PERODICTICUS (e), TARSIUS ♂ (f), TARSIUS ♀ (g), OEDIPOMIDAS (h), CEBUS (i), HYLOBATES LAR (j), HYLOBATES MOLOCH (k), MACACA, PAPIO, AND ORANG-UTAN (l), CHIMPANZEE NO. 319 (m), AND CHIMPANZEE, GORILLA, AND MAN (n)

thumb (Polak). It even may occasionally be absent in man (1.5 p. c.: Parsons and Robinson).

The second part of the extensor digitorum profundus is subject to great variability among the primates. It can supply the fingers (II-V) in at least 8 different combinations, most of which in turn are somewhat variable in detail:

(1) There is retention of the basically primitive condition, with tendons for all of the four ulnar digits (II-V) (Fig. 19f). This has been reported only as a variation in *Tarsius,* gibbon (8 p. c., or 1/13), and orang-utan (5 p. c., or 1/19). A true deep extensor of the 5th finger seems never to occur in man.

(2) Only the most ulnar element is lost, so that the muscle inserts upon digits II, III and IV. This is a very common primate arrangement (Fig. 19 d, g, j, k). It is normal for the gibbon (92 p. c.) and is of very frequent occurrence in lemurs (*Lemur, Daubentonia, Perodicticus*), *Tarsius,* and the New World monkeys of the family Cebidae (*Pithecia, Cebus, Ateles, Lagothrix*). It also is found as a variant in *Tupaia,* orang (11 p. c.), chimpanzee (4 p. c., or 1/28), and man. The deep extensor of the 4th finger, *"m. extensor annularis proprius",* is

of excessive rarity in man. Instances of its occurrence have been recorded by Testut, Le Double, and Frohse and Fränkel. I myself never have seen it. When present it takes origin from the lower ulna (Le Double).

(3) Insertion is limited to digits II and III. This is perhaps the most frequent primate arrangement (Fig. 19e, i, l). It is normal for Tupaioidea (*Tupaia, Ptilocercus*), Old World monkeys (apparently always in *Macaca, Lasiopyga, Papio, Pygathrix, Nasalis,* and *Colobus,* according to many investigators), and the orang (66 p. c.); furthermore, it also is found very frequently in lemurs (*Lemur, Daubentonia, Galago, Loris, Perodicticus*), *Tarsius* and some platyrrhines (*Cebus, Ateles*), and by no means is rare in either the chimpanzee (21 p. c.) or man (5-13 p. c.: Le Double, Wood, Wagenseil). The deep extensor of the 3rd finger, *"m. extensor medii proprius"*, can reappear in man either as a mere fasciculus of the extensor indicis proprius or as an independent muscle arising from the lower ulna. Among 48 arms (26 Negro, 22 white) especially examined for this point, A. B. Howell and myself found a deep extensor for the 3rd finger in 5 instances (3 Negro, 2 white) or about 10 p. c.; in some of these it arose autonomously from the ulna.

(4) There are two tendons, for digits II and V. Apparently this has been encountered only in *Nycticebus* (left arm) by Murie and Mivart.

(5) The two tendons insert upon digits II and IV, as in 4 p. c. of chimpanzees and the above *Nycticebus* (right arm).

(6) Insertion is upon digits III and IV, as may occur in *Alouatta* and commonly in *Callithrix*. The 2nd finger, however, receives a tendon from the ext. poll. et ind. longus.

(7) There is a single tendon for digit III. This is found in some marmosets (*Callithrix, Oedipomidas*) and has been reported for both orang (13 p. c.) and chimpanzee (4 p. c.). In both of the marmosets the 2nd finger was supplied by the ext. poll. et ind. longus (Fig. 19h), but such a tendon was lacking in the anthropoid apes (Fig. 19m). Yet the index finger of the chimpanzee (W. L. S.) received two distinct slips from the tendon of the ext. digit. communis, the more ulnar in all likelihood being nothing more than the vestige of the deep extensor tendon that had fused secondarily with the superficial extensor.

(8) There is a single tendon inserting only upon the 2nd finger (Fig. 19n). This arrangement occurs normally in man (87-95 p. c.),

gorilla (all 14 animals specifically reported upon), and chimpanzee (68 p. c.). It also has been encountered by Murie and Mivart in both *Loris tardigradus* and *Lemur variegatus* (left arm), and is an occasional variant in the orang-utan (5 p. c.). Thus man and the two African apes customarily possess a true "extensor indicis proprius". It seems clear, however, that the ulnar segment of the extensor digitorum profundus is undergoing further reduction in the gorilla. Both Bischoff (1880) and Duvernoy (1855/56) noted that the extensor indicis was but slightly developed in their animals, as was its tendon in my specimen. This is corroborated by the data collected by Hartmann (1886), Kohlbrügge (1897), Keith (1899), and Leche (1900), all of whom, furthermore, maintained that it can be lacking in the gorilla. Complete suppression is very rare in man (Frohse and Fränkel, Le Double, Testut, Wagenseil).

The precise distribution of the extra-pollical segment of the ext. profundus is effected in a variety of ways. At times there is but a single primary tendon, inserting on more than one digit. The pollical portion may be included, so that the tendon trifurcates to digits I, II and III (*Tupaia*), or the single tendon may divide terminally to II, III and IV (*Tupaia, Lemur, Tarsius*) or only II and III (*Tupaia, Ptilocercus, Lemur*) or III and IV (*Callithrix*).

In some animals there are two primary tendons, one or both of which supplies more than one digit, as II + III and III + IV (*Daubentonia, Ateles,* gibbon), II and III + IV (*Lemur, Perodicticus*), or II +III and III (*Loris, Cebus*). In this specimen of *Cebus* (Senft), II and III also received additional tendons from the pollical portion, which thus actually was an "extensor pollicis, indicis et medii longus".

There may be three primary tendons, some of which supply more than one digit. This has been recorded only for *Daubentonia* (Murie and Mivart), in which the tendons go to II + III, III + IV and IV, respectively, and for *Lagothrix* (Bang), in which they supply II, II + III and IV, respectively (II receiving also a third increment from the pollical portion).

Finally, there are separate primary tendons confined to individual fingers, as II, III and IV (*Tarsius,* gibbon), II and V (*Nycticebus*), II and IV (*Nycticebus,* one chimpanzee), II and III (many forms, as a number of lemurs, *Tarsius, Cebus,* Old World monkeys, most orang-utans, some chimpanzees), and II (occasionally in lemurs and orang, most chimpanzees and men, gorillas). It will be noted that the tendency

toward isolation of the individual digits is accentuated in the more advanced primates and has become an almost constant character in catarrhines (see Fig. 19).

Two tendons for a single digit hence are of frequent occurrence in the more generalized groups, more especially for the 2nd and 3rd fingers. That for the index digit usually acquires its second tendon from the ext. poll. et ind. longus. In *Perodicticus* (W. L. S., Fig. 19e), however, the single initial tendon passing to II splits distally to insert in two parts, one of which possibly represents the vestigial index tendon of the ext. digit. communis that has fused with the ext. profundus. Two tendons for one finger are present only infrequently in anthropoid apes and man.

Short extensors of several sorts, confined to the hand, normally occur in certain Xenarthra (*Bradypus, Choloepus, Cyclopes*), and have been found as primate anomalies in both man and *Ateles*. These, forming the so-called "extensor digitorum brevis manus", possibly represent unascended deep extensor or ulno-carpal elements. On the other hand, they may well belong to the metacarpal extensor series, with which they are more fully discussed below.

MANUAL MUSCULATURE

Metacarpal extensor series

This group of muscles is present in urodele amphibians (Fig. 1), although entirely absent in *Megalobatrachus*. It is to be seen at its maximum development in *Necturus* (if Haines and I are correct in allocating the necturine short extensors to this series instead of to the ulno-carpal extensors). Origin always is from the distal row of carpal bones, at times also from centrale or metacarpals. Insertion is upon the phalanges. There are either 3 or 4 muscle-slips: For II, III and IV in *Salamandra*: for I, II and III in *Cryptobranchus, Salamandra,* and *Necturus;* and for all four digits in *Necturus* (most examples). Partial metacarpal insertion has been reported for *Salamandra* (Eisler). These muscles commonly are termed *dorsometacarpales,* in *Necturus* (v. s.), however, "extensores breves".

The *dorsometacarpales* are very well developed in all existing reptiles (Figs. 2, 18). Regularly there is a full complement, one for each digit, but the precise morphology is somewhat variable. The origins have

migrated distally, being from the metacarpalia, although at times in part from the carpus (*Iguana*) or even from the basal phalanges (*Emys*).

True metacarpal extensors normally are lacking in mammals, except probably in certain Xenarthra (*Bradypus, Choloepus, Cyclopes*) where they seem to be represented by the so-called "extensor digitorum brevis manus". In a specimen of *Bradypus griseus griseus* Gray dissected by me the short manual extensor was strongly developed. It arose as a large fleshy mass from most of the dorsal aspect of both carpus and metacarpus, considerably fused with the underlying interosseous muscles, and inserted upon the backs of the digits. Essentially similar descriptions for the genus have been given by Humphry (1870), Mackintosh (1874), and Meincke (1911).

The muscle is much weaker in *Choloepus*. In the example of *C. hoffmanni* Peters which I studied it arose from the dorsal bases of the metacarpalia and from the carpus. The two small bellies joined the tendons of the ext. digit. communis over the digits. Humphry gave a similar account for this genus.

In *Cyclopes* (= *Cyclothurus*) the muscle is limited to a single portion arising only from the carpus and inserting upon digit III (Humphry). The second division described by Humphry, originating from the ulna and attaching to digit II, obviously is a part of the ext. digit. profundus.

An example of extensor digitorum brevis manus has been found in an *Ateles geoffroyi* (W. L. S.). This, as described above, arises as two small muscular divisions, from the profundus tendon of III and from the deep aspect of the dorsal carpal ligament, that conjointly insert upon the index finger. Apparently this is the only record of a short manual extensor in any primate other than man.

The extensor digitorum brevis manus is a well-known human anomaly. It has been observed in whites by many workers (cf. esp. Testut, Le Double, Bühler), in Chinese by Wagenseil, and by McGregor in Bantus, while I have seen it in Negroes. Wood found it in 7 per cent of English, Wagenseil in about 2 p. c. of Germans and in slightly less than 1 p. c. of Chinese. In most instances it arises only from the dorsum of the carpus, occasionally from both carpus and metacarpus, but only infrequently from the metacarpus alone. Usually it terminates in a single tendon inserting dorsally upon either digit II or digit III, less often upon digit IV. Not rarely, however, it forms 2 (to II and III, or III and IV) or even 3 (to II, III, IV) digital tendons. At times

the slips unite with the dorsal interossei. Bühler, who studied this type of anomaly in great detail, found that the slips were innervated by the deep division of the radial nerve (n. interosseus dorsalis) and hence were indubitably of the extensor musculature.

Judging from its relationships, it appears likely that the muscle of *Ateles geoffroyi* is not a vestige of the metacarpal extensor series but is an ulno-carpal extensor component with primitive, anomalous origin. The normal short digital extensor of the sloths and two-toed anteater and the similiar anomalous structure of man, however, seem very probably to represent true metacarpal extensor elements directly homologous with the dorsometacarpales of amphibians and reptiles. The entire conformation of the short extensor in these forms makes the homology appear very reasonable. This need occasion no surprise respecting the Bradypodidae at least, for the sloths—despite their many specializations—are very archaic animals.

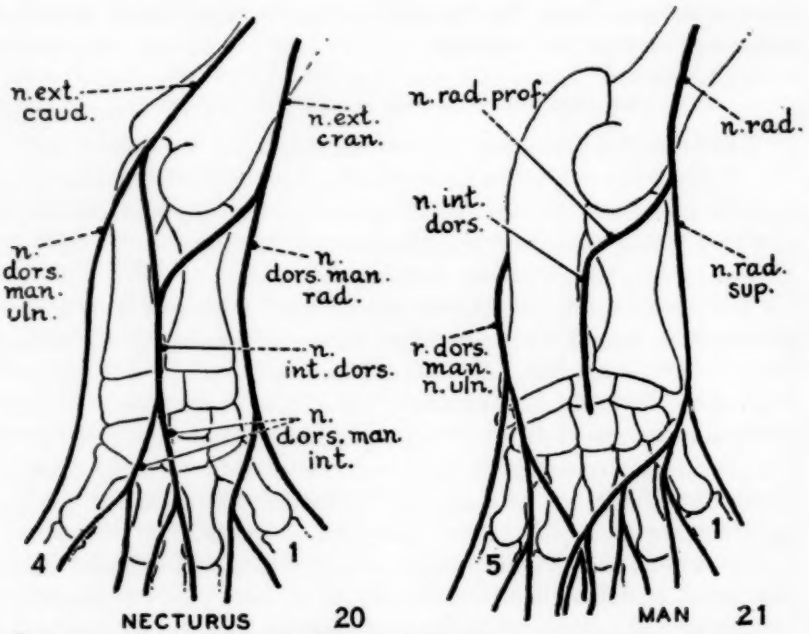
THE ANTEBRACHIO-MANUAL EXTENSOR NERVES

The following discussion is based not only upon my own dissections (in which *Necturus, Iguana, Didelphis,* and *Papio* have been given especial attention) but also upon the literature, of which the careful and very clearly presented investigations of Ribbing (1907, 1938) and Haines (1939) having proven particularly valuable.

The nerves supplying the extensor (dorsal) musculature of forearm and hand in tetrapods emanate from the dorsal stratum of the brachial plexus. The disposition of tetrapod limb plexuses in two layers—a ventral for the flexor muscles and a dorsal for the extensors—is almost universally accepted as something basic in appendicular pattern. In the more primitive tetrapods, such as urodeles and reptiles, and even in monotremes, however, although this fundamental arrangement is clearly apparent, the autonomy of the two strata of the brachial plexus by no means is complete. Anastomoses between flexor and extensor nerves, and nerves containing both ventral and dorsal fibres, are not uncommon. Perusal of the numerous diagrams of brachial plexuses in the book of Harris (1939) will amply illustrate the point. This strongly suggests that the distinct and rather sharp separation of the two strata of nerves as found in anurans, birds and therian mammals is a rather late phylogenetic occurrence.

Examination of tetrapods in general reveals that there are two main, basic dorsal nerve-trunks traversed by fibres supplying the antebrachial

extensor musculature. When they occur, these two peripheral pathways remain essentially constant in location, although their *precise* topographical relationships are subject to a certain amount of variability that seems lacking in real significance. Because of their relatively great topographical stability, the major nerve-trunks often are of considerable aid in establishing muscular homologies. But it would be a great mistake to assume that the course of a peripheral nerve-fibre is rigidly pre-ordained. The nature of peripheral nerve development definitely is against such assumption, for the nerves grow centrifugally, and the factor of least resistance, among others, probably is important in the establishment of their precise courses. The resultant gross topographical variations of nerve-trunks as affecting the relations to certain muscles of n. musculo-



FIGS. 20 and 21. DIAGRAMS SHOWING THE DORSAL ANTEBRACHIO-MANUAL NERVES IN NECTURUS MACULOSUS (FIG. 20) AND MAN (FIG. 21)

The caudal extensor nerve has disappeared in Man, leaving the cranial nerve as the sole pathway to the extensor musculature. Of the three original dorsal cutaneous nerves to the digits, only the radial (n. radialis superficialis) remains in Man; but many of the digital fibres have been shifted to a ventral pathway, eventually reaching the dorsum as ramus dorsalis n. ulnaris.

cutaneus, n. radialis, and n. peronaeus communis, for example, thus likely are of no comparative morphological value but only represent vagaries of development. Furthermore, it appears clear that homologous nerve-fibres sometimes travel by one peripheral pathway, on other occasions by yet another pathway, although the etiology of such variability as yet is unknown. Hence the composition of any single nerve-trunk may vary throughout phylogeny, and seemingly even within a single species. This, in my belief, is a most important and fundamental concept that applies to peripheral nerves in general and to those of the limb-plexuses, where the greatest possibility for re-routing exists, in particular. In the brachial plexus, at least, this variability would seem to be facilitated by the primitive tendency toward inosculation between the several nerves.

In the theoretically primitive condition (Fig. 22A), as seen in urodeles and many reptiles (Chelonia, *Sphenodon*), two dorsal nerves enter the forearm, the pre-axial *n. extensorius cranialis* and the post-axial *n. extensorius caudalis* of Seiglbauer and Haines. These two extensor rami are distinct well up in the appendage, even at shoulder or plexus. At the elbow, the cranialis passes next to the radial epicondyle of the humerus whereas the caudalis lies more ulnarward, adjoining the olecranon. The condition in *Necturus* (W. L. S.) is typical (Fig. 20). In this animal the cranialis first runs deep to the extensor radialis longus, between it and the extensor radialis brevis, innervating both of these muscles and then passing into the interosseous space of the antebrachium. Here it is joined by the caudalis, which in like manner has coursed deep to and supplied the extensor ulnaris. The two nerves unite at a variable point in the forearm deep to the extensor carpi intermedius, the resultant single trunk (*n. interosseus dorsalis*) continuing distally into the manus, innervating the humero-dorsal, ulno-carpal and metacarpal extensors in its course. The arrangement in *Salamandra* (Haines, Ribbing) appears to be quite similar. In other urodeles (as *Megalobatrachus, Triton, Siren, Amblystoma*), however, and in *Sphenodon* and Chelonia (*Emys, Chrysemys, Testudo*), the dorsal interosseous nerve receives an anastomotic branch from the volar interosseous nerve of the flexor stratum of the plexus (Fig. 22A). It is not possible absolutely to decide whether this communication represents the primitive state, as Haines believes. Nevertheless, in view of the aforementioned archaic ten-

dency toward communication between flexor and extensor nerves, it appears quite likely that such anastomosis was more or less basic.

From this ground-plan (A), evolution has proceeded in at least two directions. One trend comprised increasing diversion of extensor axons into peripheral flexor pathways, leading finally to nearly complete atrophy of both of the primary extensor rami beyond the elbow. This arrangement seems to be peculiar to lacertilian reptiles, in which—consequent to the almost complete suppression of the primitive dorsal antebrachial pathways—the chief nerve of the extensor surface is a branch of n. interosseus volaris (ventralis) of the flexors (Fig. 22B). Conditions in *Iguana* (W. L. S.) can be taken as more or less representative. N. extensorius caudalis is entirely absent, so that the only dorsal nerve to reach the antebrachium constitutes an abbreviated n. extensorius cranialis that ends in the humero-radial extensors. Just beyond the point where n. interosseus volaris passes dorsal to the ulno-palmar flexor mass, it gives off a branch that perforates the interosseous fascia and innervates the more proximal extensor muscles. Following this, a

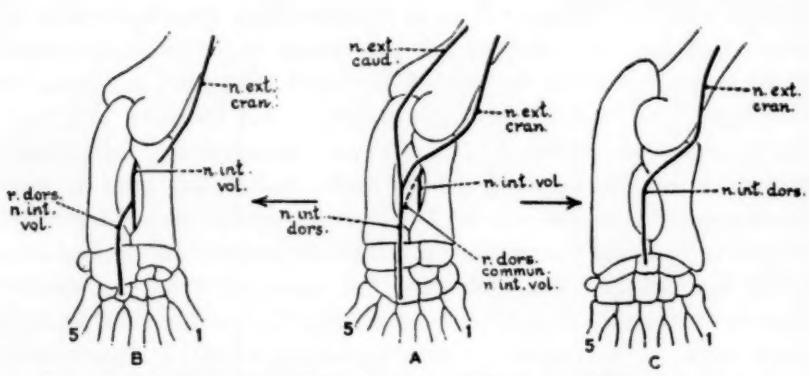


FIG. 22. DIAGRAMS SHOWING THE TWO PHYLOGENETIC TRENDS IN THE DORSAL ANTEBRACHIO-MANUAL NERVES

The cutaneous branches are not shown. A. Primitive, symmetrical arrangement, with cranial and caudal nerves uniting to form the dorsal interosseous nerve (Urodela, *Sphenodon*, Chelonia); a communicating branch from the volar interosseous nerve to the dorsal interosseous nerve frequently occurs. B. Reduction of the primary dorsal pathways to an abbreviated cranial nerve, the chief extensor nerve of the antebrachium being an enlarged ramus communicans of the volar interosseous nerve (lacertilian reptiles). C. Dominance of the cranial nerve (n. radialis) consequent to disappearance of the caudal nerve and any communication with volar trunks (Anura, Mammalia).

second flexor branch, similar but larger, pierces the interosseous space. It serves the remaining extensor muscles of antebrachium and manus, passing distally in the manner of the dorsal interosseous nerve of *Necturus*. This is fundamentally in agreement with the accounts given by both Rabl (1915) and Howell (1936b). Conditions in other lacertilians are similar (Brooks, Haines, Harris, Ribbing). It is easy to see how such a condition could have evolved from the urodele-turtle pattern (A). This merely would require proximal consolidation of antebrachial flexor and extensor fibres into a common trunk, with utilization by the latter axons of the primitive communicating bridge between the two interosseous nerves to enter the dorsal forearm and hand.

The second evolutionary trend in the dorsal nerves leads to the mammals and, curiously enough, also to the anuran amphibians (Fig. 22C).[2] It involved changes from the primitive arrangement (type A) that were far less extreme than those producing type B. In mammals, the n. extensorius cranialis is well developed, being none other than the *n. radialis*, the chief dorsal trunk of the appendage proper. Near the elbow it gives off twigs to m. brachioradialis (and often to other muscles of the humero-radial extensor sector) and then enters the forearm, where it becomes the *n. interosseus dorsalis* (or deep radial nerve) in the fashion of *Necturus*. This is the sole pathway for nerve-fibres to the dorsal musculature of forearm and hand: For not only has all communication with the volar interosseous nerve been lost (if ever present), but the n. extensorius caudalis has been wholly suppressed, unless Brooks and Haines are correct in assuming that the so-called "nerve to m. anconaeus" (a brachial branch of the radial nerve) represents an abbreviated remnant of that pathway. In any instance, since the anconaeus is of the triceps complex, the caudal extensor nerve plays no part in the innervation of forearm and hand, and it is reasonable to

[2] According to both Ribbing (1907, 1938) and Haines (1939), the Crocodilia resemble mammals and anurans in that n. extensorius cranialis is the sole extensor nerve of the forearm, the caudal extensor nerve and the communicating branch between the interosseous trunks each having disappeared. If Harris (1939) is correct, however, at least many crocodilians are intermediate between the urodele-turtle (type A) and the lacertilian (type B) patterns: For while there always is a true dorsal interosseous nerve, it either receives a communicating flexor contribution, or, in the absence of the latter structure, the antebrachial extensors are innervated by a perforating volar interosseous branch somewhat as in *Iguana*. It is not impossible that in this respect the Crocodilia are evolving in the direction of the Lacertilia.

suppose that its components have been diverted to the cranial pathway. It appears not unlikely, however, that the proximal, brachial portion of n. extensorius caudalis persists as an entity distinct from the cranial nerve in monotremes (see especially Howell, 1937, and Harris). The available data on this point are somewhat obscure, and further investigation of these animals with basic tetrapod conditions in mind might prove extremely profitable. Finally, in anurans there can be no doubt respecting the complete disappearance of n. extensorius caudalis, for not even a "nerve to the anconaeus" is present. Instances suggestive of the presumably archaic communication between the dorsal interosseous nerve and flexor trunks have been reported as rare variations in man (see Schäfer and Symington, 1909). This deep radial anastomosis may be with either the volar interosseous (as in more primitive tetrapods) or with the ulnar nerve. Rauber-Kopsch (1907) claimed that some sort of union of the two interosseous trunks through the interosseous membrane is a frequent occurrence in man. Fitzwilliams (1909-10) found that a large branch of the median (volar interosseous?) nerve joined the dorsal interosseous nerve in a gibbon, *Hylobates agilis*. These instances lend support to the view that such a communication existed in the ancestors of the Mammalia but has since disappeared as a normal feature incidental to the more complete segregation of the dorsal and ventral motor components of the brachial plexus.

Although, as Haines has noted, the courses of the main nerve trunks in general are remarkably constant among the several classes of vertebrates, some minor variability is manifested. As the n. extensorius cranialis enters the forearm, it customarily passes deep to the entire group of humero-radial muscles; but it sometimes pierces this sector as in *Sphenodon* (Brooks) and a few urodeles (*Necturus, Salamandra*) and mammals (*Phalangista*, primates). In a similar way, its distal extension, n. interosseus dorsalis, exhibits topographical variability relative to the deep or antebrachio-manual layer of muscles. In reptiles and urodeles it runs ventral to that layer (Haines), but not in therian mammals. Thus, in *Didelphis* (W. L. S.) it does not course along the interosseous membrane (Fig. 16) but pierces the abductor pollicis longus; in *Papio papio* (W. L. S.) and commonly in man (Fig. 17) it is dorsal to the deep extensor proximally but eventually passes ventral to the extensor pollicis longus; while at times in man, as well as in the marsupials *Thylacinus* and *Phalangista* (Cunningham), it lies wholly between the superficial and deep matrices of muscles.

The cutaneous nerves exhibit a number of phylogenetic changes and are less stable than the muscular trunks. A good account for amphibians and reptiles, with figures, has been given by Haines (1939). Apparently there are three primary, distinct cutaneous nerves to the dorsal podium: (1) *N. dorsalis manus radialis,* branching from the cranial extensor nerve about the elbow; (2) *n. dorsalis manus intermedius,* from the dorsal interosseous nerve; and (3) *n. dorsalis manus ulnaris,* given off by the caudal extensor nerve at a variable location in the antebrachium (Fig. 20). Of these, the intermediate ramus seems originally to have been the most extensive, with the other divisions restricted to the border of the manus.

Where the caudal extensor nerve is absent (anurans, crocodilians, lizards, mammals) the ulnar cutaneous fibres are re-routed peripherally. Hence, in *Rana* n. dorsalis manus ulnaris is a distinct division of the dorsal interosseous nerve; while in *Alligator, Varanus,* and Mammalia it is a branch from the flexor surface that passes dorsalward around the ulnar border of the distal forearm or hand, the so-called *ramus dorsalis manus n. ulnaris* (Fig. 21). The latter condition also is seen in *Sphenodon,* although there is a caudal extensor nerve; perhaps this foreshadows a disappearance of that pathway. The true dorsal nature of the fibres comprising the dorsal manual branch of the ulnar nerve also has been recognized by Appleton (1911) and Harris (1939).

The ramus intermedius is well developed in urodeles, but its territory already has been invaded by the marginal rami. In *Necturus* (W. L. S., Fig. 20), the ramus radialis supplies the skin of the first digit and the adjoining side of the second, the ramus intermedius the skin bordering the second and third interdigital clefts, and the ramus ulnaris the ulnar border of the fourth digit. *Salamandra* (Haines) is similar, except that the ulnaris (which branches from the dorsal interosseous nerve) has replaced the intermedius in the third cleft. The ulnaris covers the same area in *Megalobatrachus* (Haines), but the radialis innervates only the radial margin of the first digit.

All of the branches in *Rana* are derived from the cranial extensor nerve. The radial and ulnar rami are primitively confined to the borders of the manus, the intermediate supplying the remaining area.

Conditions are basically symmetrical in many reptiles. The radial and ulnar divisions are limited to the free borders of the marginal digits in *Emys, Sphenodon,* and *Varanus* (Haines), so that the intermediate ramus is very extensive. R. ulnaris is a flexor branch in the latter two

genera. In *Alligator* (Haines) the ulnaris has spread radialward to innervate the fourth cleft.

In monotremes (Brooks, Haines, Harris, Westling) the ramus radialis is remarkably large and supplies all of the digits. The deep radial pathway has no cutaneous component. Indeed, in *Echidna* there actually is no dorsal interosseous nerve, for the deep division of the cranial extensor nerve terminates in muscular branches high in the antebrachium.

The ramus ulnaris regularly is a branch of the ulnar flexor nerve (r. dorsalis manus n. ulnaris) in therian mammals, for, as noted above, the caudal extensor pathway is completely suppressed. There is a decided tendency for the ramus radialis (n. radialis superficialis of mammals) to be absent in marsupials. In *Phalangista* (Cunningham) it is replaced by a dorsal branch of the median nerve of the flexors that supplies the two radial digits, while the ramus intermedius (from the dorsal interosseous nerve) and the ramus ulnaris each supply one and one-half. *Thylacinus* (Cunningham) differs somewhat, for there is no intermediate branch, the median nerve now innervating three and one-half digits and the ramus ulnaris the other one and one-half; hence all of the dorsal cutaneous fibres have shifted to a flexor pathway, an extreme specialization. *Didelphis* is variable, for while the ramus radialis can be lacking (Fig. 16) and its area taken over by the ramus intermedius (W. L. S.), all three primary cutaneous branches can occur (Haines). In the latter instance, each marginal ramus innervates one and one-half fingers.

The domestic cat (Reighard and Jennings) has no ramus intermedius. The ulnaris (r. dorsalis manus n. ulnaris) supplies the ulnar one and one-half digits, the radialis (n. radialis superficialis) the remainder.

The ramus ulnaris is more restricted in *Ptilocercus* (Clark) than in the actual primates, being distributed to the ulnar margin of V and anastomosing with a branch of the radial division to supply the fourth cleft. There is no ramus intermedius.

Conditions in *Tarsius* (Woollard) are identical with those in the cat, for there is no intermediate nerve and the ulnaris innervates one and one-half digits, the radialis three and one-half. This also seems to be the customary arrangement in monkeys, for it has been reported in *Cebus, Lasiopyga, Macaca, Papio, Pygathrix,* and *Nasalis* (Höfer, Kohlbrügge, Howell and Straus). In both *Macaca* and *Papio,* however,

the musculocutaneous nerve can supply the thumb and the radial and ulnar rami may overlap in the third cleft.

Kohlbrügge (1890) found that his three specimens of Hylobatidae (*Hylobates moloch, H. agilis, Symphalangus syndactylus*) differed in detail, but all were primitive in the possession of a well-developed interosseous cutaneous branch or ramus intermedius. This, which always innervated the second cleft, covered one to two fingers, the radial ramus one or one and one-half, and the ulnar one and one-half or two and one-half.

The orang-utan resembles the gibbons in the apparent normality of a ramus intermedius (Kohlbrügge, 1897). The two radial nerve branches serve most of the fingers, r. ulnaris being distributed only to the ulnar one and one-half as in a majority of monkeys. Ramus radialis goes to one and one-half (Höfer) or two and one-half digits (Westling), r. intermedius to the ulnar three interdigital clefts. A musculocutaneous branch can reach the thumb (Höfer). Thus there apparently is a considerable nerve overlap, a feature that becomes accentuated in man.

In the chimpanzee, r. radialis can supply three and one-half fingers, r. ulnaris one and one-half (Höfer); or the latter branch can replace the radial in the third cleft (Gratiolet and Alix). A ramus intermedius, to the second cleft, has been noted (Hepburn), the radialis and ulnaris supplying the digits on either side.

An intermediate cutaneous branch seems not to have been found in the gorilla. Ramus ulnaris innervates two and one-half fingers (Hepburn, Höfer, Eisler cited by Kohlbrügge, 1897), r. radialis two and one-half (Eisler, Hepburn) or three and one-half (Höfer).

The dorsal cutaneous supply of the fingers is notoriously variable in man and frequently has been discussed (Fig. 21). In extreme instances the superficial radial nerve (ramus radialis) supplies all five fingers, or the dorsal ulnar (ramus ulnaris) four. There may be a considerable overlapping, as through anastomosis. From a study of 300 Poles, Kosinski (1927, cited by Loth, 1931) concluded that the normal distribution of the radial involves two and one-half fingers (47 per cent). He believed that there has been a phylogenetic reduction of the radial field with accompanying increase of the ulnar, and that this still is in progress. This of course is but another way of stating that the fibres tend increasingly to be re-routed over ventral pathways, so that the dorsal divisions disappear. A cutaneous branch of the dorsal interosseous nerve (ramus intermedius) is not normal but occasionally

has been noted to supply the second cleft (see Schäfer and Symington). In rare instances the superficial radial nerve is entirely lacking, with replacement by the lateral antebrachial cutaneous branch of the musculocutaneous nerve (Appleton, 1911), so that all of the original dorsal pathways have disappeared, much as in some marsupials.

The phylogeny of the dorsal cutaneous supply of the digits revolves, therefore, about an increasing tendency—for some obscure reason—toward shifting of the fibres over peripheral ventral pathways (cf. Figs. 20 and 21). The first step in this direction apparently was connected with the loss of the caudal extensor nerve of the antebrachium and involved ventral re-routing of the ulnar digital axons. Following this, the intermediate or dorsal interosseous pathway was suppressed in many forms, and even the radial route in some. The logical conclusion of this process is complete disappearance of the primitive dorsal nerves. Marked progress in this direction already has been made in marsupials, and is distinctly suggested in man. The great variability in distribution of the rami, obvious in many forms of animals, probably is indicative of a continuing change.

CONCLUSIONS

The homologies of the antebrachial and manual extensor muscles in urodeles, lizards, mammals (basic), and man are presented in condensed form in the accompanying table. This will serve as a general summary. A few points, however, deserve further discussion.

It is to be noted that the three superficial or brachio-antebrachial groups exhibit a marked phylogenetic trend toward distal migration. This is evident in their insertions, which at first are concerned chiefly with radius and ulna, rather than with manus. But the antebrachial insertion tends to become relatively reduced or even lost and the manual insertion increases in importance. Hence the marginal series, originally without any great action on the podium, come to produce strong movement of that segment as a whole, supplementing the activities of the intermediate and deeper groups; while the extensor humero-dorsalis, at first a simple extensor of the podium, finally becomes the primary digital extensor. Similarly, the origins of these muscles exhibit a tendency, among mammals, to supplement or even relinquish their primitive humeral attachments by migration over the elbow-joint, thereby gaining connections with the bones of the antebrachium. This is very evident not only in the marginal sectors but also in the central or intermediate group.

It is well advanced in the anthropoid apes, especially the gibbons, possibly in correlation with brachiation, for the muscles then can act upon the hand without strongly affecting the elbow-joint. But the occurrence of a similar trend in man—less well marked in some respects—is no argument for a brachiating ancestry, inasmuch as it is found not only in more generalized, non-brachiating primates but also to some extent in mammals of other orders. Undoubtedly this tendency toward distal migration of origin is an archaic one, and its strong development in different groups results from diverse stimuli. The most notable exception to this trend is the brachioradialis, which exhibits proclivity toward proximal recession.

Conversely, the antebrachio-manual extensor series experiences marked proximal migration during phylogeny, at least with respect to origin, ascending the forearm deep to the humero-antebrachial muscles. The arrangement of the mammalian forearm extensors in two distinct strata largely is the result of the opposed migratory tendencies in the two series.

It is noteworthy that the superficial group along the radial margin of the antebrachium (the humero-radial) experiences a more extensive phylogenetic differentiation into separate muscles than does the corresponding group on the ulnar border (the humero-ulnar). The radial group of mammals had four muscles, the ulnar but two. This possibly is related to the fact that so many movements of forearm and hand are toward the pre-axial border or the head.

Mammalian innovations among the antebrachio-manual extensor musculature fall into three categories: (1) The development or rather differentiation of new, distinct muscles, namely, the extensor digiti V proprius and extensor pollicis brevis. This process has been surprisingly limited, indeed to such an extent that the short pollical extensor is found in but a single order. (2) The regression of muscles or muscle groups. Affecting only the primitive wrist matrix, this includes the disappearance of the dorsometacarpales and the tendency toward reduction of the extensor digitorum profundus. (3) Marked migration affecting either origin or insertion, or both. This is a rather widespread, although not entirely universal, tendency. It includes the migrations of the superficial marginal muscles, the complete transformation of the extensor carpi intermedius into the extensor digitorum communis, and the proximal translocation of the ulno-carpal extensors.

TABLE 1

Homologies of the antebrachio-manual extensor muscles in representative tetrapods

	BASIC PLAN	URODELES	LIZARDS	MAMMALS (BASIC)	MAN
Brachio-antebrachial group	Ext. humero-radialis	Ext. rad. longus Ext. rad. brevis	Ext. rad. longus Ext. rad. brevis	Brachioradialis ? Ext. c. rad. longus Ext. c. rad. brevis Supinator	Brachioradialis ? Ext. c. rad. longus Ext. c. rad. brevis Supinator
	Ext. humero-dorsalis	Ext. c. intermed.	Ext. c. intermed.	Ext. digg. communis	Ext. digg. communis
	Ext. humero-ulnaris	Ext. ulnaris	Ext. c. ulnaris	Ext. c. ulnaris Ext. IV. et V prop.	Ext. c. ulnaris Ext. dig. V prop.
Antebrachio-manual group	Ulno-carpal Ext. Series	Supinator manus	Abd. poll. longus	Abd. poll. longus	Abd. poll. longus Ext. poll. brevis
		Ext. digg. brevis	Ext. digg. brevis	Ext. digg. prof.	Ext. poll. longus Ext. indicis prop. (Ext. medii prop.) (Ext. annul. prop.)
Manual group	Metacarpal Ext. Series	Dorsometacarpales	Dorsometacarpales	(Ext. digg. brev. manus)	(Ext. digg. brev. manus)

The Primates, as an order, exhibit but few peculiarities when compared with other mammals: (1) Very marked tendency for certain condylar muscles (as supinator, ext. carpi ulnaris, etc.) to arise from bones of the forearm, and (2) perforation of the supinator by the deep radial nerve.

A number of characters, however, are found among primates only in one or more of the animals comprising the so-called "group of higher primates" (gibbons including siamang, orang-utan, chimpanzee, gorilla, man). These are: (1) Tendency for the supinator entirely to relinquish its humeral origin (orang and gorilla, as variant in both); (2) extreme differentiation of humero-radial extensor sector (man, as variant); (3) accessory ulnar origin for extensor digitorum communis (gibbon, usually; all 3 great apes, as variant); (4) advanced isolation of the individual tendons of the common extensor (usually in all except gibbon); (5) tendency to form an ulnaris digiti V (in chimpanzee and, especially, man, as variant); (6) origin of extensor digiti V proprius usually not directly from humerus (gibbon, from ulna; man and gorilla, from common extensor); (7) normal reduction of extensor digitorum profundus so as to include only thumb and index finger (man, gorilla, chimpanzee); and (8) occurrence of an extensor pollicis brevis (man, normally; gibbon and, especially, gorilla, as variant). These characters, in combination, furthermore suggest a community of origin for man and anthropoid apes. But the ways and degrees in which the common potentialities have developed obviously are highly variable. This readily is comprehended when one realizes that the several animals have been subjected to entirely different stimuli. Thus the three great apes undoubtedly are possessed of a long brachiating ancestry. The line leading to man, however, in my definite belief, never passed through a brachiating stage worthy of mention.

The Hylobatidae have developed in their own direction and have adapted themselves to brachiation in their own way. Hence it is not surprising that they exhibit specializations peculiar to them among the man-ape group: (1) Very high insertion of the brachioradialis; (2) frequent accessory insertion of the extensor carpi radialis longus on the metacarpal of the thumb; and (3) very marked tendency for the superficial antebrachial muscles to arise from the shaft of the ulna.

The three great apes collectively differ from man chiefly respecting the following points: (1) Amount of extension possible at the wrist (less in the apes than in man); (2) tendency towards extreme differenti-

ation of the humero-radial sector (greater in man); (3) extent of subdivision of the extensor digitorum communis (usually more in man); (4) frequency of an ulnaris digiti V (greater in man); and (5) frequency of an extensor pollicis brevis (greatest in man). Man is the more specialized in 4 of these 5 characters (nos. 2, 3, 4, 5), the great apes in the other one (no. 1). In the great apes, as in most mammals, the extensors of forearm and hand essentially are muscles of recovery, for the process of brachiation primarily is a function of the flexors. Hence their peculiar mode of locomotion, involving over-development of the flexors, likely has been a most important factor in limiting the evolution of the extensor musculature in the anthropoids. The upper extremity of man, however, has been freed of the exigencies of bodily support, permitting a wider range and variety of manual function. This is reflected in the human extensor musculature, which, although still subordinate in action to the flexors, is more highly differentiated than that of any other primate.

The original pattern of the dorsal forearm nerves appears to have been symmetrical, with pre-axial (cranial) and post-axial (caudal) divisions uniting to form an axial (interosseous) trunk. It is probable that there was anastomosis with flexor nerves. The two major developments from this condition involved simplification of peripheral pathways. In lacertilian reptiles, the primitive dorsal routes have almost completely disappeared and the axons incorporated into the main flexor trunk. In mammals, on the other hand, parsimony has been attained through suppression of all pathways except the pre-axial; while gross segregation of flexor and extensor nerve-fibres has become accentuated instead of obscured as in lacertilians. Conditions among therian mammals are surprisingly uniform and there appear to be no important differences.

The dorsal cutaneous pathways to the digits are experiencing phylogenetic simplification in that the number of primary branches tend to become reduced. This is accomplished largely through a curious transference of fibres to ventral pathways, an apparently universal trend among tetrapods.

There may very well be a relatively constant phylogenetic relationship between a given striated muscle and its particular motor neurons, as believed by most comparative myologists. If this general concept be accepted—and myology tends to be chaotic without it—then the striking phylogenetic variability in macroscopic, peripheral innervation of

the antebrachio-manual extensors must be explained. According to the well-known Fürbringer hypothesis, which regards the precise peripheral innervation as paramount, the extensor muscles of lacertilians, for example, cannot be considered as homologous to those of mammals. If, however, we assume, as I have done, that homologous nerve-fibres for some obscure reason can and at times do adopt diverse peripheral pathways, we arrive at a more reasonable explanation of the variability in peripheral innervation; furthermore, the muscles of lizards and mammals then appear homologous. To this extent, in its failure to consider transference of nerve pathway, the Fürbringer hypothesis is extremely vulnerable. That it has served a great purpose in bringing order into myology, cannot be denied. But its rigid application can be stultifying, unless one be inclined to assume that Nature is incredibly capricious in the production of vicarious muscles. I am of much the same opinion as Cunningham (1882b), that while the peripheral innervation of a muscle is extremely valuable in determining its homology, it is not infallible—since there exists much evidence that re-routing of nerve-fibres can and does occur, as by central anastomosis and fasciculation. The reaction of Haines (1935) to the Fürbringer hypothesis—practically denying the value of nerve-supply outside a single class of vertebrates—seems, however, much too extreme.

SUMMARY

1. There are 3 basic groups of extensor muscles associated with antebrachium and manus in tetrapods: Brachio-antebrachial, antebrachio-manual, manual. The first is derived from the elbow matrix, the others from the wrist matrix.

2. The brachio-antebrachial group exhibits 3 divisions: Humero-radial, humero-dorsal, humero-ulnar. Extensor humero-radialis is represented in mammals by the exts. carpi radiales longus et brevis, supinator, and probably brachioradialis. Extensor humero-dorsalis becomes the mammalian ext. digit. communis. Extensor humero-ulnaris forms the ext. carpi ulnaris and ext. dig. V proprius of mammals. Both the origins and (especially) the insertions of these muscles undergo distal phylogenetic migration.

3. The antebrachio-manual group is represented by the mammalian abductor pollicis longus and ext. digit. profundus. The human ext. pollicis brevis is derived from the long abductor. These muscles

experience proximal phylogenetic migration, so that the forearm muscles appear as two distinct strata.

4. The manual group comprises the dorsometacarpales of amphibians and reptiles. They have disappeared in mammals, with probable rare exceptions.

5. The forearm extensors of man are more specialized than those of the great apes. This probably is related to the freedom of the human upper extremity from a rôle in bodily support.

6. The dorsal nerve-trunks of the antebrachium are primitively symmetrical, with pre-axial and post-axial divisions uniting to form an axial trunk. Anastomosis with flexor nerves probably is basic. The post-axial pathway is lost in mammals, the pre-axial (and terminal axial) remaining as n. radialis. All communication with flexor trunks has disappeared.

7. The dorsal cutaneous nerves of the digits undergo simplification, largely through suppression of the primitive dorsal branches and transference of the axons to ventral routes.

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FORM DISCRIMINATION TEST AS GIVEN TO NAVAJO, NEGRO AND WHITE SCHOOL CHILDREN

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THIS Form Discrimination Test[1] consists of a series of 48 pairs of circles and near circles. One radius is used throughout for the circular arch, but the imperfect circles are composed of two arches with two centers united by a curved line. The distances between these centers varies regularly. There are twelve degrees of imperfect circles in the 48 pairs presented. In each pair of circles one is perfect, and the other is imperfect.

A similar set of 44 pairs of octagons was presented and the examinee was told: "One of these is always perfect, with all the sides the same length and all the corners the same; the other figure is always imperfect —out of shape in one or more ways." There were eleven degrees of imperfect octagons in the 44 pairs used.

A similar book containing 52 pairs of triangles was given the examinee who was told to select the one of the pair that was most perfectly symmetrical. There were thirteen degrees of imperfect triangles in the 52 pairs of triangles presented.

Each of these three tests was made on the racial groups shown in Table 1. In Table 3 are shown the number of persons tested in each group.

All these children were examined and scored for each test. The average score of each group for each age was determined. The frequencies for each age varied from 2 to 34, the youngest ages having

[1] This Test was designed under the direction of C. B. Davenport and published by the Eugenics Record Office, Cold Spring Harbor, New York. The Test is described in the Eugenics Research Association Monograph Series, III, p. 197. The author wishes to express his thanks to Dr. Davenport for kind suggestions made during the progress of this work.

TABLE 1. *Lines of least squares of form discrimination scores for male and female children of four racial groups*

GROUP	LINE OF LEAST SQUARE ERROR OF SCORES FOR DIFFERENT AGES	
	Average	Slope
Dutch boys — Circles	$Y = 79.825$	$+ 0.595x$
Dutch boys — Octagons	$Y = 84.048$	$+ 0.949x$
Dutch boys — Triangles	$Y = 74.350$	$+ 1.116x$
Dutch boys — All tests	$Y = 79.408$	$+ 0.887x$
Dutch girls — Circles	$Y = 80.161$	$+ 1.237x$
Dutch girls — Octagons	$Y = 82.011$	$+ 1.149x$
Dutch girls — Triangles	$Y = 73.425$	$+ 0.354x$
Dutch girls — All tests	$Y = 78.532$	$+ 0.913x$
Jamaica white males — Circles	$Y = 72.702$	$+ 2.217x$
Jamaica white males — Octagons	$Y = 78.326$	$+ 3.167x$
Jamaica white males — Triangles	$Y = 69.332$	$+ 1.308x$
Jamaica white males — All tests	$Y = 73.453$	$+ 2.231x$
Jamaica white females — Circles	$Y = 68.648$	$+ 2.042x$
Jamaica white females — Octagons	$Y = 74.992$	$+ 3.571x$
Jamaica white females — Triangles	$Y = 66.328$	$+ 1.929x$
Jamaica white females — All tests	$Y = 69.989$	$+ 2.514x$
Jamaica colored males — Circles	$Y = 75.265$	$+ 2.869x$
Jamaica colored males — Octagons	$Y = 80.639$	$+ 2.171x$
Jamaica colored males — Triangles	$Y = 71.513$	$+ 1.879x$
Jamaica colored males — All tests	$Y = 75.806$	$+ 2.306x$
Jamaica colored females — Circles	$Y = 74.640$	$+ 1.971x$
Jamaica colored females — Octagons	$Y = 79.059$	$+ 2.116x$
Jamaica colored females — Triangles	$Y = 71.738$	$+ 1.788x$
Jamaica colored females — All tests	$Y = 75.146$	$+ 1.958x$
Navajo Indian males — Circles	$Y = 77.317$	$- 0.085x$
Navajo Indian males — Octagons	$Y = 78.514$	$- 0.512x$
Navajo Indian males — Triangles	$Y = 74.957$	$- 0.175x$
Navajo Indian males — All tests	$Y = 76.929$	$- 0.257x$
Navajo Indian females — Circles	$Y = 74.344$	$+ 1.406x$
Navajo Indian females — Octagons	$Y = 79.020$	$- 0.858x$
Navajo Indian females — Triangles	$Y = 72.304$	$+ 0.967x$
Navajo Indian females — All tests	$Y = 75.223$	$+ 0.505x$
All males — Circles	$Y = 76.277$	$+ 1.399x$
All males — Octagons	$Y = 80.382$	$+ 1.444x$
All males — Triangles	$Y = 72.538$	$+ 1.032x$
All females — Circles	$Y = 74.448$	$+ 1.664x$
All females — Octagons	$Y = 78.771$	$+ 1.495x$
All females — Triangles	$Y = 70.949$	$+ 1.260x$

small numbers. A statistical analysis was made and later checked independently by Mr. Philip Lawrence and Mr. Henri Seibert, assistants in the department.

The method employed in analyzing the scores was the fitting of a straight line by "least squares" to a set of points based on unequal frequencies. Such a line is designated by the formula $Y = a + bx$ where Y is equal to the average score for a particular age, x (x being the coded value of the actual age). a represents the average score at the coded age zero or actual age of 13.5 years. b represents the slope of the straight line and thus indicates the amount of improvement in percentage per year of age in form discrimination. Table 1 presents the equations of the lines obtained.

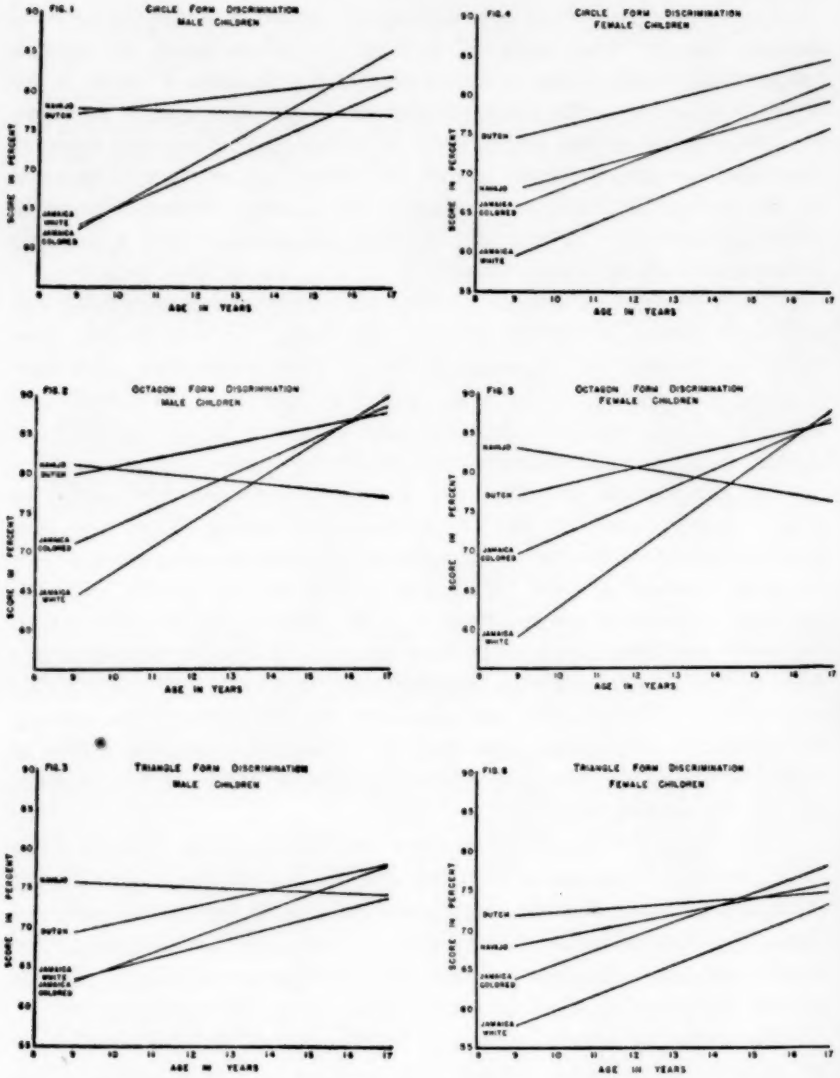
Where the second term is positive the score is improving with age within the limits of the age groups considered. Where, on the other hand, the second term is negative the score is diminishing with age, showing a decreasing ability to make discriminations of the form. The second term has in all cases positive value, except in Navajo Indian boys' circles, octagons, and triangles and in Navajo girls for octagons.

For comparative purposes the foregoing formulae are plotted in Figs. 1 to 9. It will be seen in the graphs for males (Figs. 1-3) that there is a marked similarity throughout the three forms of tests. Of the three races that show improvement with age, the Dutch have the best scores, Jamaica colored next, and the Jamaica whites the poorest. However, the latter two groups show more rapid improvement with age than do the Dutch, attaining approximately the same score at the last age studied. Navajo boys are dissimilar to the other groups, having the highest score at young ages and no subsequent increasing ability at form discrimination which results in the lowest scores at the terminal age of the investigation.

The graphs for females show less similarity of pattern than do those of the males. Here again, however, the Dutch show for the most part the best scores over the age range considered, with Jamaica colored and Jamaica whites following in that order. Again the Navajos are rather erratic and show the least amount of improvement with age. In the case of the octagons, their scores decreased decidedly with age.

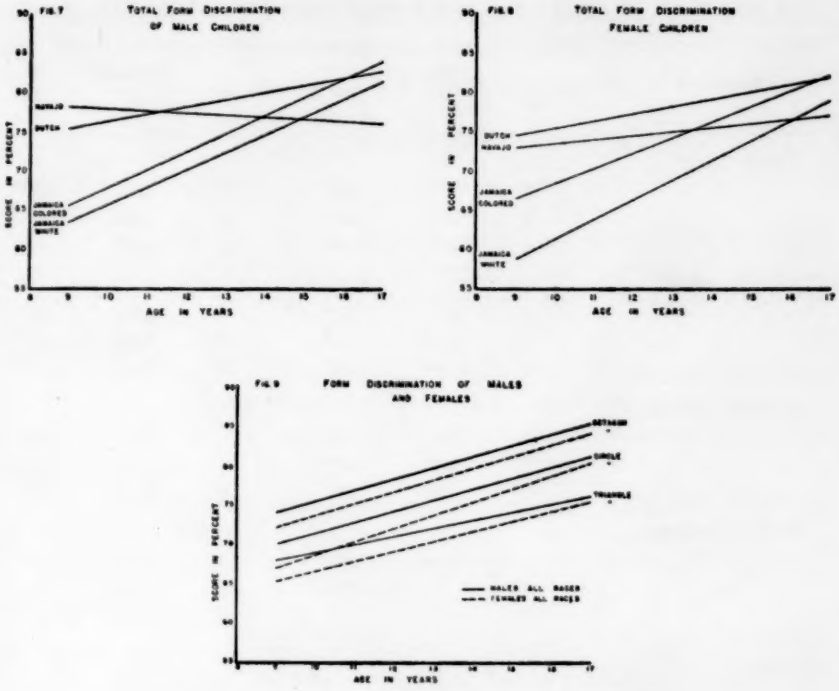
The similarity between male and female pattern of form discrimination for the four groups is well demonstrated by a comparison of the graphs (Figs. 7 and 8) showing the totals for the two sexes, all tests grouped together.

Lines of Least Squares for Form Discrimination Test



FIGS. 1-6

LINES OF LEAST SQUARES FOR FORM DISCRIMINATION TEST



FIGS. 7-9

Figure 9 presents the material irrespective of race. It is at once obvious that the octagon test is the easiest, and that the triangle test is not only the most difficult but also offers the greatest obstacles of improvement with age. Male children show a superiority over female children in each type of form discrimination, but the slopes of the lines indicate that the girls improve at a slightly more rapid rate than do the boys.

The regression coefficients were tested for significance, and Table 2 gives the values of "*t*" and the approximate probability of occurrence of such a value, or one greater, in a hundred samples. From Table 2 it may safely be concluded that Dutch and Jamaica (both white and colored) male children showed a significant improvement with age for all tests. The declining trend in male Navajoes, however, is not signifi-

TABLE 2

The values of "t" of the regression coefficients for the 4 racial groups

RACE	TEST	MALES			FEMALES		
		N	*t*	*P*	*N*	*t*	*P*
Dutch white							
	C	9	2.66	.03	8	3.41	.01*
	T	9	2.70	.02	8	.92	.40
	O	9	2.87	.02	8	3.28	.01
Jamaica white							
	C	9	4.02	.01*	8	4.15	.01*
	T	9	6.38	.01*	8	8.25	.01*
	O	9	11.82	.01*	8	5.13	.01*
Jamaica colored							
	C	8	5.74	.01*	9	6.91	.01*
	T	8	6.78	.01*	9	5.00	.01*
	O	8	3.00	.01	9	9.61	.01*
Navajo Indians							
	C	9	.13	.90	9	4.38	.01*
	T	9	.34	.75	9	1.26	.25
	O	9	1.64	.15	9	2.03	.07

* Indicates a probability of less than one in a hundred.

cant. Jamaica females (both white and colored) showed significant improvements with age for all tests. This is also true for Dutch females for circles and octagons, but not for triangles. The improvement in the Navajo females is significant only for the circle test, that for octagons doubtfully so, but the downward trend for triangle is not definitely significant.

Table 3 gives the biometric constants of the results obtained from these tests. From these figures the difference in mean scores and the probable error of the differences among the three types of discrimination tests can readily be determined.

It may be seen that the males have, as a group, significantly better scores than the females, the difference being $1.54 \pm .25$ or $6 \times PE$ of the difference. This difference in the two sexes is especially evident among the Jamaica whites.

TABLE 3

Biometric constants of the results obtained in the form discrimination test on the four racial groups

RACE	TEST	MALES			FEMALES		
		N	Mean Score	St. Dev.	*N*	Mean Score	St. Dev.
Dutch white							
	C	150	80.37±0.45	8.15±0.32	117	80.25±0.50	7.96±0.35
	T	150	74.83±0.44	8.00±0.31	117	74.18±0.55	8.84±0.39
	O	149	83.06±0.63	11.36±0.44	115	81.89±0.68	10.86±0.50
Jamaica whites							
	C	91	75.04±0.76	10.73±0.54	100	69.35±0.70	10.44±0.50
	T	105	70.59±0.59	8.94±0.41	100	67.45±0.54	8.01±0.38
	O	94	79.67±0.81	11.65±0.57	100	73.67±0.84	12.51±0.60
Jamaica colored							
	C	132	76.64±0.62	10.61±0.44	164	75.88±0.48	9.06±0.34
	T	142	72.37±0.44	7.83±0.31	164	72.74±0.48	9.17±0.34
	O	137	80.91±0.66	11.42±0.46	164	80.24±0.57	10.93±0.41
Navajo Indians							
	C	146	78.60±0.44	7.97±0.31	129	77.57±0.55	9.29±0.39
	T	148	76.27±0.54	9.70±0.38	131	74.30±0.54	9.14±0.38
	O	145	79.09±0.62	11.10±0.44	126	78.70±0.61	10.09±0.43
Totals		1589	77.46±0.18	10.59±0.13	1527	75.92±0.18	10.49±0.13

In all cases the octagon tests were the easiest, significantly better scores were made as compared to triangles in all cases, and as compared to circles in the majority of cases. In all instances the triangles were the most difficult, significantly so when compared to circles, and especially so when contrasted to octagons.

DISCUSSION

The fact that boys do better than girls for every age and in each racial group considered may mean that lines, circles and angles have more of an appeal for them than they do for girls. An answer to the

question why Navajo female scores increase so slightly with age and those of Navajo males actually decrease with age, while those of three other racial groups increase rapidly with age is problematical. The author suggests that the incidence of trachoma among the Navajos may be the possible explanation for this phenomenon.

NOTES

ON THE DISTRIBUTION OF THE DIFFERENCES BETWEEN BIRTH DATE AND DEATH DATE

NOTE ON AN INQUIRY BY THE LATE RAYMOND PEARL

FOREWORD

IN connection with a project of investigation which Dr. Pearl was planning his curiosity was aroused about the form and characteristics of the distribution of the fractions of year given by the differences between month and day of birth and month and day of death. Apparently the question had never been considered or, at least, reported upon and therefore Dr. Pearl with the aid of a student, Mr. Myron L. Simpson, set about to seek the answer for himself. The results which he had obtained before his untimely death are described below. At the suggestion of Mrs. Raymond Pearl and of Prof. Lowell J. Reed the writer has undertaken to annotate and order the findings. Except for minor additions and the computation of the statistical constants by Mr. Joseph Kish this note presents the data as they were elaborated by Dr. Pearl himself, who also briefly commented on them verbally at a departmental seminar. However, the writer is responsible for the following discussion.

I

Two series of birth and death dates were employed for the purpose of this inquiry. The first series was collected by Mr. Simpson incidental to another study he was making. From the *Dictionary of American Biography,* Volumes I and V, and Volume II, pp. 1-420 inclusive, he transcribed the required information with reference to all the persons married at least once and whose month, day, and year of birth and of death are recorded. The second series was collected by Dr. Pearl from the *Standard Dictionary* (Funk and Wagnalls, 1913) starting with the

letter F (Fabricius, J. A.) through the letter H (Hyrtle, J.). The only condition for inclusion in the second series was that the biographical sketch mentioned the month, day, and year of both birth and death. The first series will be termed hereafter Amer. Biog., the second will be called Stand. Only the data on the men have been used in the analysis which is concerned with 1011 differences taken from the Amer. Biog. series and 1085 from the Stand. series. To compute the fraction of year between birth date and death date the table prepared by Pearl and Miner[1] was used. When death occurred earlier in the year than the birth the difference is preceded by a + (plus) sign, when it occurred later in the year the difference is preceded by a — (minus) sign.

II

The distributions of the differences between birth date and death date for the two series separately and combined are illustrated in Fig. 1, and in Table 1 are presented the statistical constants of the distributions.

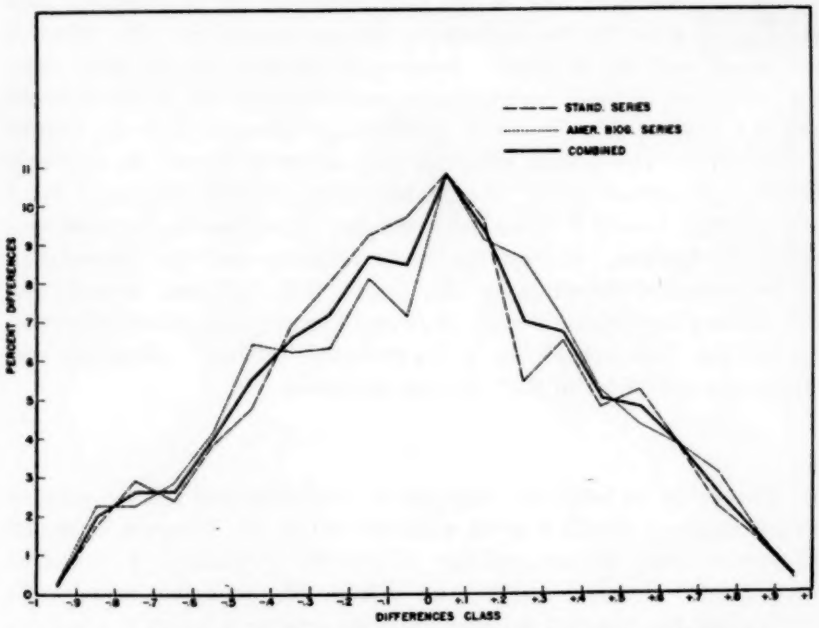


FIG. 1. FREQUENCY OF DEATHS ACCORDING TO DIFFERENCES BETWEEN BIRTHDAY ANNIVERSARY AND DATE OF DEATH

[1] Pearl, R. 1940. Introduction to Medical Biometry and Statistics. 3d. edit. *Philadelphia and London* (W. B. Saunders Co.). Pp. 514-515.

TABLE 1

Biometric constants of the distributions of differences between birthday anniversary and death date

CONSTANT	SERIES		
	Amer. Biog.	Stand.	Combined
N	1011	1085	2096
Mean	+.0150±.0087	+.0027±.0082	+.0086±.0060
σ	.4121±.0062	.4012±.0058	.4065±.0042
β_1	+.0051±.0014	.0000±.0000	+.0010±.0002
β_2	2.3705±.0453	2.4944±.0504	2.4309±.0325

From the tabulation and the graph the following points are worthy of note:

1. The form of the distribution of the differences is the familiar cocked-hat shape.

2. The differences center around zero as a mean.

The value of β_2 being significantly less than 3, according to the Pearsonian system a Gaussian normal function would not describe the distribution as well as a type II curve. However, this is beside the point which is that a unimodal distribution, quasi-normal it could be said, concentrated around a difference of zero is obtained. On the average the fraction of year between birth day and death day is, therefore, practically nil and on their face these findings would seem to indicate that persons tend to die on or around their birthday anniversary.

III

Before an attempt can be made to interpret the above results it is well to consider carefully what the differences discussed actually represent. If a person born on January 1 died on December 31, in the above scheme the difference between birth date and death date equals —.997. Instead, for another person born on January 1 but who died on January 2 the recorded difference would be +.003. Thus, although the actual interval between death and birth date is the same in both cases, the difference as expressed here covers half the range of all the possible differences. So, notwithstanding that the average difference between

birth date and death date approximates zero it does not mean that average interval between birth date and death date is zero.

A second point to consider is that the range of the differences between birth date and death date depends upon the birth date. For example, when the birth date occurs between January 1 and 19 the range of the differences is limited from +.049 to —.997; when the birth date lies between July 3 and July 20 the range of the differences is +.548 to —.499; for birth dates between December 14 and December 31 the limits vary from +.997 to —.049. (As a matter of record, Pearl adopted a division of the year into twentieths instead of months or weeks. The reasons need not be discussed here.) It becomes immediately apparent from these examples that not only does the range of the possible differences depend upon the birth date but, in addition, the probability for small differences is greater than for large ones *because of the classification employed.*

In view of these considerations, especially, Pearl was led to determine the distribution of differences expected if the deaths were spread equally throughout the year. This theoretical distribution was obtained by calculating for the n persons born within a certain interval (twentieth of a year) the number for whom a given difference between birth date and death date would have been found if all death dates occurred with equal frequency. This number is, of course, given by $\frac{n}{s}$, where s is the range of the possible differences for persons born in the stated interval according to Pearl's scheme. Implicit in this theoretical distribution is the assumption that there is no seasonal fluctuation in mortality. If it is assumed that there is no seasonal factor acting upon either birth date or death date, then a theoretical distribution could be computed by considering that on the basis of a random assortment of birth dates and death dates the distribution of the differences would be represented by an isosceles triangle having as base the whole range of the differences ($2r$ classes) and as height $\frac{N}{r}$ where N is the total number. The theoretical distributions calculated by the former method (A) and by the latter method (B) are compared with the observed data in Table 2.

From Table 2 it is clearly apparent that the calculated distributions A and B are practically the same. The A distribution is not perfectly symmetrical probably because it is influenced by the fluctuation of births within the year. Both calculated distributions resemble closely the observed distribution. The deviations between observed and theoretical

TABLE 2

Observed differences between birthday anniversary and death date, and theoretical differences calculated according to methods A and B (see text)

DIFFERENCES CLASS	OBSERVED	CALCULATED A	CALCULATED B
—.999—.900	5	9.86	10.48
—.899—.800	42	30.91	31.44
—.799—.700	55	54.54	52.40
—.699—.600	55	76.32	73.36
—.599—.500	84	95.36	94.32
—.499—.400	117	113.32	115.28
—.399—.300	138	133.52	136.24
—.299—.200	151	156.66	157.20
—.199—.100	182	176.75	178.16
—.099—.001	177	199.48	199.12
+.000—.099	227	199.77	199.12
+.100—.199	196	178.56	178.16
+.200—.299	146	154.89	157.20
+.300—.399	141	133.38	136.24
+.400—.499	105	114.44	115.28
+.500—.599	101	96.58	94.32
+.600—.699	80	75.75	73.36
+.700—.799	55	53.08	52.40
+.800—.899	31	32.76	31.44
+.900—.999	8	10.07	10.48
Total	2096	2096.00	2096.00

A give a chi-square of 25.64 with a P of .14; between observed and theoretical B the deviations result in a chi-square of 24.47 with a P of .18. Therefore, it may be concluded that a distribution similar to the observed can result when the deaths take place with equal frequency throughout the whole year and independently of birth date. It would follow also that, while according to the method of computing the fractions of year that separate date of death from birth anniversary the average difference is zero, if the differences had been computed on the basis of "last" birthday then the average difference would be 6 months and the distribution could be represented by a rectangle, instead of a unimodal curve or triangle.

ANTONIO CIOCCO

THE PAN-AMERICAN LEAGUE AGAINST CANCER

AN organization which is to carry on in the Western Hemisphere the scientific and social work of the International Union Against Cancer has been incorporated under the laws of the State of New York as the Pan-American League Against Cancer. One may recall that the International Union Against Cancer was an organization actively engaged in the fight against cancer on an international scale. Fifty-two countries were affiliated with the International Union which maintained headquarters at Paris, France, until recent events.

The creation of the Pan-American League is due to the efforts of Professor Francis Carter Wood of New York, Professor Angel H. Roffo of Buenos Aires and Mr. Boris Pregel, respectively vice-president, member of the Board of Directors and president of the Finance Committee of the International Union Against Cancer, with the cooperation of many other outstanding personalities in the field of cancer and members of the International Union Against Cancer, throughout the American continent. Professor Francis Carter Wood headed the Organizing Committee of the new League and the presidency will be assumed by Angel H. Roffo, Professor of Cancerology at the University of Buenos Aires, Founder and Director of the Instituto de Medicina Experimental, the leading institution for cancer research in Latin America.

The Organizing Committee also included, among others interested in cancer:

Dr. Leonardo Guzman, Director-General of the Public Health Services and Director of the National Institute of Radium, Santiago, Chile;

Dr. A. Fontes, Director of the Instituto Oswaldo Cruz, Rio de Janeiro, Brazil;

Dr. A. Prudente, President of the Sao Paulo Association to Fight Cancer; Sao Paulo Brazil;

Dr. Fernando Ocaranza, President of the Mexican League Against Cancer, Mexico City, Mexico;

Dr. Emilio Martinez, President of the Cuban League Against Cancer, Havana, Cuba;

Dr. J. E. Gendreau, Director of the Institute of Radium of the University of Montreal, Montreal, Canada;

Prof. J. V. Huertas, Director of the National Institute of Radium, Bogota, Colombia;

Dr. Modesto Arreaga Gomez, Guayaquil, Ecuador;

Dr. Luis Manuel Debayle, Surgeon General and Director of Public Health, Managua, Nicaragua;

Dr. Juan Jose Mostajo, President of the Cancer League of Peru and Director of the Institute of Cancer, Lima, Peru;

Dr. Julio Garcia Alvarez, Minster of Health and Social Welfare, Caracas, Venezuela;

Dr. Leon Rulx, Director-General of the National Service of Hygiene and Public Welfare, Port-au-Prince, Haiti;

Dr. Mario Lujan, Secretary of Health, San Jose, Costa Rica;

Dr. Solon Numez, Head of Hygienic Education and Former Minister of Health, San Jose, Costa Rica;

Dr. M. Beltranena Director of the General Hospital, Guatemala, C. A.;

Dr. Carlos Martinez Duran, Professor of Pathological Anatomy at the University of Guatemala, Guatemala, C. A.;

Dr. Alfonso Pruneda, Permanent Secretary of the National Academy of Medicine, Mexico City, Mexico;

Dr. Carlos Zuckermann, Director, Clinica Mexicana de Cirugia y Radioterapia, Mexico City, Mexico;

Dr. Jose Fabella, Commissioner of Health and Welfare of the Philippines, Manila, P. I.;

Dr. Carlos Barillas Munoz, Director, Hospital Rosales, San Salvador, C. A.;

Dr. Carlos Butler, Director, Institute of Cancer of Montevideo, Montevideo, Uruguay, etc.

The incorporators of the Pan-American League Against Cancer are:

Winthrop W. Aldrich, Chairman of the Board of Directors of the Chase National Bank, New York City;

Ira A. Campbell, Lawyer, New York City;

Thomas M. Debevoise, Lawyer, long a director of the American Society for the Control of Cancer;

General J. G. Harbord, Chairman of the Board of Directors of the Radio Corporation of America, New York City;

Dr. Frank B. Jewett, President of the National Academy of Sciences and Chairman of the Board of Directors of the Bell Telephone Laboratories, New York City;

Gilbert LaBine, Member of the Board of Governors of Toronto University, Toronto, Canada;

Mrs. Robert G. Mead, Member of the Board of the New York Committee of the American Society for the Control of Cancer, New York City;

Dr. George E. Pfahler, Professor of Radiology of the University of Pennsylvania, Philadelphia, Pa.;

Boris Pregel, President of the Finance Committee of the International Union Against Cancer, New York City;

Dr. Benjamin Rice Shore, Surgeon at St. Luke's Hospital, New York City;

Dr. Albert Soiland, Radiologist, Los Angeles Tumor Institute, Los Angeles, Cal.

Dr. Howard C. Taylor, Gynecologist and Consultant to many hospitals, Member of the Board of Directors of the American Society for the Control of Cancer;

L. W. Tomarkin, former Secretary-General of the International Union Against Cancer and Secretary-General of the Permanent Bureau of the International Congress of Physics, Chemistry and Biology;

Dr. Francis Carter Wood, Professor Emeritus, Columbia University, Vice-President, International Union Against Cancer.

The aims of the new organization, as outlined in the certificate of incorporation are:

a. To promote and encourage the international fight against cancer.

b. To coordinate in the countries of the American continent the scientific study and research in cancer and to publish and disseminate information thereon.

c. To engage in social welfare work in its relation to the problem of cancer.

d. To promote the establishment of national organizations throughout the Western Hemisphere to engage in similar activities.

The comprehensive program of the activities of the Pan-American League will include, it is hoped:

a. Publication of a Pan-American Cancer Journal to serve as a permanent medium of information on the activities of the League and its affiliated national organizations.

b. Organization and maintenance of a Pan-American center of information and statistics on cancer.

c. Establishment of a Pan-American system of fellowships, scholarships, endowments and exchange of scholars and students.

d. Among its immediate projects are:

The organization of a First Pan-American Cancer Week to be held simultaneously in all the countries of the American continent on the pattern of the First International Cancer Week of 1938, which was held simultaneously in forty countries throughout the world. The holding of a Pan-American Congress for the Scientific and Social Fight Against Cancer.

It is anticipated that this Congress will take place at Buenos Aires in 1942 under the chairmanship of Professor Angel H. Roffo and the honorary presidency of His Excellency, Dr. Roberto M. Ortiz, President of the Argentine Republic. The Congress will coincide with an Exhibition devoted to the scientific, social and technical aspects of the fight against cancer, sponsored by the Pan-American League Against Cancer.

Among the incorporators we find such outstanding pioneers in the fight against cancer as Professor Francis Carter Wood, Dr. Howard C. Taylor, Mrs. Robert G. Mead, and Mr. Thomas M. Debevoise, who, in 1922, were the incorporating members of the American Society for the Control of Cancer.

We also note among the founders Mr. Boris Pregel, who is a prominent figure in the international movement against cancer, being president of the Finance Committee and member of the Executive Committee of the International Union Against Cancer.

The Board of Directors includes the most prominent representatives of medical science in the field of cancer and public health in general throughout the American continent. The Pan-American character of

the new organization is stressed by the fact that some twenty countries of the Western Hemisphere are represented on the Board of Directors either by outstanding Central and South American cancer specialists or by high officials of governmental health and hygiene departments of the countries concerned. In addition, the Argentine Government has extended its patronage to the Pan-American League Against Cancer.

ERRATUM

IN the article by Rachel M. Jenss, "Gain in weight and its association with ancestry and economic status," which appeared in HUMAN BIOLOGY, vol. 12 December, 1940, pp. 532-544, the following footnote was omitted:

"Grateful acknowledgment is made to Dr. Susan P. Souther, formerly on the staff of the Children's Bureau, now with the Connecticut State Board of Health, who supervised the field work and made the medical examinations for the New Haven Study of Physical Fitness, on which this report is based."

RECENT LITERATURE

USEFUL IN THE STUDY OF HUMAN BIOLOGY

In this department will be noticed the books and reprints which are currently received at the Editorial Office. Publications intended for notice here should be addressed to Dr. Lowell J. Reed, Chairman of the Board of Associated Editors of Human Biology, 615 North Wolfe Street, Baltimore, Maryland, U.S.A.

I. EVOLUTION AND GENETICS

1. *Evolution—General Principles*

HENSHAW, PAUL C., ROBERT W. WILSON, HILDEGARDE HOWARD, ALDEN H. MILLER, JACK F. DOUGHERTY, and RICHARD H. JAHNS. Studies of Cenozoic Vertebrates and Stratigraphy of Western North America. *Contributions to Paleontology. Publication* No. 514. *Washington, D. C.* (Carnegie Institution of Washington), 1940. Pp. iii + 194 + 24 plates + 1 folding map. 10 × 6¾ inches. $2.75 (paper); $3.25 (cloth). [Bibliographic footnotes throughout.]

2. *Human Evolution*

[Vacant]

3. *Prehistory and Archaeology*

BREUIL, HENRI, *Abbé*. A remarkable painted cave on the estate of Lescaux (Montignac, Dordogne). *Nature*, Vol. 147, pp. 12-13, 1941.

BUSHNELL, DAVID I., JR. Evidence of Early Indian Occupancy near the Peaks of Otter, Bedford County, Virginia. *Smithsonian Miscellaneous Collections*, Volume 99, No. 15. *Washington, D. C.* (Smithsonian Institution), 1940. Pp. 14 + 5 plates. 9½ × 6¼ inches. 20 cents (paper). [9 bibliographic footnotes.]

MARTIN, PAUL S., JOHN RINALDO, and MARJORIE KELLY. The SU Site Excavations at a Mogollon Village, Western New Mexico 1939. *Anthropological Series, Field Museum of Natural History* Vol. 32, No. 1. *Publication* 476. *Chicago* (Field Museum of Natural History), 1940. Pp. 97 + 11 maps. 9½ × 6⅜ inches. $1.50 (paper). [Bibliography of 1¼ pages.]

WILLIAMS, ARTHUR B. Geology of the Cleveland Region. Pocket Natural History No. 9. Geological Series No. 1. *Cleveland, Ohio* (Cleveland Museum of Natural History), 1940. Pp. 61. 6¾ × 4¾ inches. 50 cents (paper).

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